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ORIGINAL ARTICLES.

I.—The Centenary of the Geological Society of London.

IN January last we referred to the celebrations in honour of this important event.[1] We have now the pleasure to call attention to the "History of the Geological Society of London,"[2] a work which has been written by Mr. Horace B. Woodward, F.R.S., F.G.S., in commemoration of the Centenary. Mr. Woodward has had the help of Mr. H. W. Monckton, Treasurer, who has described the Medals of the Society, Mr. R. S. Herries, M.A., V.P., who supplies a correct version of the Charter, and Professor E. J. Garwood, M.A., Secretary, who undertook to deal with illustrations. Sir A. Geikie, K.C.B., President, Professor Watts, F.R.S., Secretary, Professor Bonney, F.R.S., and Dr. H. Woodward have assisted by reading the proofs, but they are "not responsible for any individual statements" except where expressly acknowledged. These and other persons are duly thanked for the help afforded.

The result of Mr. Woodward's laborious researches has been the production of a book of the greatest possible interest, and one which should be read, not merely by the Fellows of the Geological Society, but by all geologists interested in the history of their science. It is a record of first-class importance, and is, on the whole, a fair and accurate account of the events which have occurred in the Geological Society up to 1860, for the later years are perhaps too fresh in the memories of many to allow of that pleasing view obtained by distance.

Opening with a rapid sketch of the histories of academies and learned societies before 1800 and a note on early geological researches in England, the author refers to the Askesian Society, which, founded in 1796, became the parent of the British Mineralogical Society in 1799. Amalgamating in 1806, these two Societies apparently threw off a "Geological Dinner Club" on 13th November, 1807, which club consisted of the following thirteen members:—Arthur Aikin (1773–1854), William Allen (1770–1843), William Babington (1750–1833),

[1] Arranged to take place at Burlington House, London, commencing on Thursday, September 26th, and ending September 30th, 1907, under the presidency of Sir A. Geikie, K.C.B., F.R.S.

[2] "The History of the Geological Society of London," by Horace B. Woodward, F.R.S. 8vo; pp. 336, with 23 portraits and 5 illustrations of medals awarded by the Society. (London: published by the Geological Society, Burlington House, August, 1907. Price 7*s.* 6*d.*; to Fellows, 6*s.*)

Jacques Louis Comte de Bournon (1751–1825), Humphry Davy (1778–1829), James Franck (–1843), George Bellas Greenough (1778–1855), Richard Knight (–1844), James Laird (–1840), James Parkinson (–1824), William Hasledine Pepys (1775–1856), Richard Phillips (1778–1851), and William Phillips (1773–1828). It was resolved at this meeting (particulars of which are to be found in the first Minute Book of the Society) :—

"That there be forthwith instituted a Geological Society, for the purpose of making geologists acquainted with each other, of stimulating their zeal, of inducing them to adopt one nomenclature, of facilitating the communication of new facts, and of ascertaining what is known in their science, and what yet remains to be discovered.

"That the gentlemen present, with Mr. Pepys and Mr. William Phillips, who have been prevented from attending this meeting, be considered the first members of the Geological Society.

"That henceforth members be chosen by ballot. Any person desirous of becoming a member, having communicated his wish through the Secretary to the Society, without being proposed or recommended in any other manner, shall be balloted for at the next meeting. The election to be unanimous.

"That no person resident in London attend more than two meetings of the Society without becoming a member.

"That each member shall be at liberty to introduce a visitor, under the preceding regulation.

"That the Society dine together, at the Freemasons' Tavern, on the first Friday of every month, from November to June inclusive, at 15*s.* per head, visitors to pay as well as members. Dinner to be on the table at five o'clock precisely. Fine for non-attendance 10*s.* 6*d.* Any member may avoid this fine by sending notice to the Secretary of his intention to be absent, three days before the meeting.

"That at the last meeting in June a subscription be raised to defray incidental expenses incurred by the Treasurer for the purposes of the Society.

"That G. B. Greenough, Esq., M.P., be treasurer, and Dr. Laird secretary, for the ensuing year.

"That a book be provided for recording the minutes of the Society and for the insertion, by members and visitors, of any geological intelligence that may be presented. Every communication must be signed by the person who makes it.

"(Signed) G. B. Greenough."

The meetings of the Society and its Committees appear to have been held in a room temporarily engaged at the Freemasons Tavern. The Society thus began its existence much in the form of a geological dining club, a feature which gradually disappeared. Moreover, the system of fines was not a success, for in June, 1809, it was announced that though the fines amounted to £37 16*s.*, £6 16*s.* 6*d.* only had hitherto been received.

On December 4th, 1807, the Right Hon. C. F. Greville was invited to become the patron, Mr. Greenough was elected the first president, and Mr. W. H. Pepys became treasurer. It was also decided that forty-two persons be elected honorary members of the Society, and these seem to have been chosen from all parts of the British Islands, and to have included such men as Richard Bright of Bristol, Joseph Carne of Penzance, J. J. Conybeare and John Kidd of Oxford, E. D. Clarke and John Hailstone of Cambridge, Robert Jameson and John Playfair of Edinburgh, Richard Kirwan of Dublin, and others.

An extraordinary omission occurs in this list of names, that of William Smith, and it is recorded by John Phillips that Smith was "almost unnoticed, except by visits from Mr. Greenough, the

president, Sir James Hall, and a few other members to examine his collections in Buckingham Street (March, 1808)."

The first communications brought before the Society were by Mr. Knight, who recorded his results obtained from melting Rowley Rag, and by Count Bournon, who showed specimens illustrative of the varieties of compact felspar.

Two Vice-Presidents were added on January 1st, 1808, and on the same day a Committee appointed to draw up the regulations of the Society presented its statement, which was adopted. As early as April, 1808, a Committee was formed "to examine papers *previously* to their being read to the Society, and to take charge of all presents that may be received."

The first printed "List of Members" bears date 1808, and in 1809 rooms were engaged, in the name of Leonard Horner, on the ground floor at No. 4, Garden Court, Temple, for the reception of its cabinet and for the meetings of the Committees.

In 1809 a "Plan for consolidating the Geological with the Royal Society as an Assistant Society" was proposed. This plan seemed not so much an attempt at consolidation as at suppression, for it proposes that "the subscribing members who are Fellows of the Royal Society shall constitute the first class or Council of the Geological Society, and be invested with the power of electing members or making byelaws," etc., while "the Royal Society may select such papers as it may please to read at its table and to print in the *Philosophical Transactions*," and such other papers may either be deposited in the collection of the Geological Society or included in any publication which it may think proper to undertake at its own charge. This plan was very properly dismissed by resolution "That the propositions communicated from the Right Hon. Charles Greville, having a direct tendency to render this Society dependent upon, and subservient to, the Royal Society, are inadmissible."

In March, 1809, the foundation of the present magnificent library was commenced, and by November the specimens in the Museum had been arranged geographically.

In 1810 more extensive premises were obtained at 3, Lincoln's Inn Fields; in the same year trustees were appointed, and it was decided that cards recording the dates of the meetings be printed and sent to each member prior to the commencement of the session. A Council was also formed, and held its first meeting on July 14th, 1810.

The first volume of the publications of the Society, called *Transactions*, appeared in 1811, and this and the successive volumes are remarkable, not only for the classical papers they contain, but for the wealth of illustration. The *Proceedings* followed in 1827 as a method of communicating more rapidly to the Fellows the affairs of the Society, and these were incorporated in the well-known *Quarterly Journal* in 1845; while the present form of *Abstracts of Proceedings* dates from May 20th, 1857, although they have been technically *published* only since 1905.

Perhaps the most important publication issued by the Society was Greenough's "Geological Map of England." This he commenced in 1808, knowing quite well of the existence of William Smith's map

(published in 1815) and being largely indebted to it for the completion of his own. It cost £1,300, of which £200 went to Webster for drawing, £111 19*s*. 9*d*. for copperplates, £914 10*s*. 3*d*. to Neele for engraving, and £73 10*s*. for paper. It was issued by Messrs. Longman, Rees, & Co. at £6 6*s*. in six sheets with a memoir, and members were allowed to purchase it for £5 5*s*.

An unofficial dining club was started in 1824 and has existed to the present day; it is limited to forty members, who dine together before proceeding to the meetings. A charter of incorporation was obtained from H.M. King George IV on April 23rd, 1825, and the title 'Fellow' became fixed by the members being so designated in this document. This charter cost £385 14*s*. 6*d*., and Babbage calculated how much the 'F.G.S.' cost each Fellow per letter.

In 1828 the Society obtained rooms in Somerset House from the Lords Commissioners of His Majesty's Treasury, through the mediation of the President and Council of the Royal Society, and the apartments so allowed to them were adapted to their purposes by Decimus Burton, who was a Fellow of the Society. Here the Society remained until 1874, when the Government transferred the accommodation to the present Burlington House, Piccadilly, where the Society, it is hoped, has found a permanent home.

W. H. Fitton seems to have been the first president whose annual address was printed, in 1827, and since that year, with the single exception of Warburton, the Presidents have delivered an annual address, dealing either with the progress of the science, or, a few notable exceptions, with some new matter distinguished by its brilliancy of thought and its originality.

Such, then, is in brief the history of the Geological Society of London, so ably set forth by Mr. Woodward in this volume. But not content with this history, Mr. Woodward has woven around his central story a general sketch of English geology wherever and whenever it comes in contact with the Geological Society. We learn the outlines of the troubles between Murchison and Sedgwick, and the extraordinary action of the Society with regard to Sedgwick; the difficulties with Beete Jukes, and Searles Wood, and Charles Moore, and the troubles of the woman question. We have presented to us an account of the Ordnance and Geological Surveys, the colouring of geological maps, the Museum of Practical Geology, catalogues of fossils, early collectors, and the cataloguing of geological literature. We see the figures of the old giants rise before us, and meet again with Lyell, Macculloch, Phillips, Mantell, Scrope, 'King' Cole, De la Beche, and scores of others, of whom many anecdotes are recorded, and of some of whom excellent portraits are given. We read afresh the old discussion on Buckland's famous memoir on the Evidences of Glaciers in Scotland, based on Agassiz' observations; we hear that caustic remark of Owen when he referred to Falconer as "that distinguished *botanist*"; and we long to possess that letter of Sedgwick's addressed to Murchison in 1853 which ended "Ever (whether in peace or war) your affectionate old friend, A. Sedgwick." We attempt to picture the size of John Miller, who had to make a rush for the door of the four-wheeler in order to get through; we

hear the chuckle of Professor Lapworth when he had written "The Secret of the Highlands"; and we decide not to devote ourselves to rock classification.

So far as this history is concerned it is fairly fully dealt with up to 1860, but after that date exigencies of space and other considerations have necessitated brief treatment. The volume has a good coloured reproduction of Buckland, carrying his well-known bag, for frontispiece; while portraits are given of Babington, Greenough, William Phillips, Macculloch, W. D. Conybeare, Sedgwick, Murchison, Fitton, Scrope, Lyell, William Smith, De la Beche, Godwin-Austen, John Phillips, Mantell, Falconer, E. Forbes, Prestwich, Jukes, Ramsay, Blanford, and A. Geikie. Most of these are excellent, but what effect John Phillips would now make if he marched down Piccadilly in those trousers it is difficult to imagine. Illustrations of all the medals awarded by the Society are given, and the volume closes with lists of the early members, lists of the staff, and others, and an efficient index. It reflects high credit on the author, and on the Society. We thank both, and congratulate Mr. Woodward on a labour of love happily conceived and admirably carried out.—S.

II.—Note on Two Rare Forms of *Actinocamax* from the English Upper Chalk.

By G. C. Crick, A.R.S.M., F.G.S., of the British Museum (Natural History).

THE present note relates to two specimens. One was obtained by Mr. G. E. Dibley, F.G.S., from the *Micraster cor-anguinum* zone of the Chalk at Gravesend, and now forms part of the British Museum collection (register number C. 10576); the other is in the collection of Dr. H. P. Blackmore, F.G.S., of Salisbury (to whom I am indebted for the loan of the fossil), and was obtained from West Harnham, near Salisbury, at the base of the zone of *Actinocamax quadratus*. Being the more nearly perfect, the Salisbury specimen is described first.

Actinocamax Blackmorei, n.sp.

Description.—The specimen (Fig. 1), which is almost perfect, is 94 mm. long, and has a smooth surface; it is fusiform, and has its greatest thickness at a point which is a little nearer the posterior than the anterior end. Here the guard is depressed, its dorso-ventral and transverse diameters being 13·75 and 15 mm. respectively. From this point the guard tapers evenly and slowly towards the anterior end, and evenly and slowly towards the posterior end, but shortly before the extremity is reached it contracts somewhat rapidly, and forms a fairly acute, almost mucronated point; the extreme tip, however, is wanting. Sponge-borings can be plainly seen beneath the surface. Viewed laterally the ventral and dorsal surfaces of the anterior three-fifths of the guard are nearly parallel, the dorsal surface in this view appearing to be nearly straight and the ventral feebly swollen. Whilst the greater part of the guard is depressed, the anterior fifth is decidedly compressed. The truncated anterior surface is flat and almost at right-angles to the axis of the guard; it is oval, its ventro-dorsal

and transverse diameters being 11·5 and 10·5 mm. respectively, the greatest width being a little nearer the ventral than the dorsal surface. There are no traces either of a ventral fissure or of the alveolus. The dorso-lateral grooves are well-preserved; at the anterior end of the fossil they are rather broad, flattened, very slightly concave, about 6 mm. apart, and each about 4 mm. wide; proceeding from this end each narrows rather rapidly for about 28 mm., being then only about 2 mm. wide; the two grooves separate rather quickly from each other for about one-half the length of the specimen; they are then continued nearly parallel to each other over another fourth of the length of the guard, when they gradually disappear.

Measurements.

	mm.
Length	94
Dorso-ventral diameter at the most inflated part	13·75
Transverse diameter at ditto	15
Dorso-ventral diameter at anterior end	11·5
Transverse diameter at ditto	10·5

Affinities and differences.—In a dorsal aspect the specimen bears some resemblance to M. Janet's figure (fig. 5*a*) of the dorsal surface of *Actinocamax Alfridi*,[1] but that species is more lanceolate and has the posterior portion of its guard less inflated than the present specimen; whilst in a lateral aspect the anterior half of the guard of this specimen tapers less rapidly than in that species. Compared with M. Janet's figures of *Actinocamax Grossouvrei*,[2] the present

[1] Bull. Soc. géol. France, sér. III, tom. xix, No. 9 (Nov., 1891), pp. 720, 721, pl. xiv, fig. 5, and text-fig. 4. M. Janet does not give the dimensions of the single specimen upon which he based the species, but, taken from his figures, they are as follows:—Length, 96 mm.; dorso-ventral diameter at the most inflated part, 14 mm.; transverse diameter at ditto, 15 mm.; dorso-ventral diameter at the narrowest part, which is at about the level of the ovisac, 9 mm.; transverse diameter at ditto, 8 mm.

[2] Bull. Soc. géol. France, sér. III, tom. xix, No. 9 (Nov., 1891), pp. 716–719, pl. xiv, figs. 1–3, and text-figs. 2, 3. For the sake of comparison with the forms described in the present paper, the dimensions of M. Janet's co-types of *Actinocamax Grossouvrei* are here given:—

	I.	II.	III.
Length in millimetres	97 (?)	97	91
Dorso-ventral diameter at the most inflated part	16	14	13
Transverse diameter at the most inflated part	20	18	15
Dorso-ventral diameter at the narrowest part, nearly at the level of the ovisac	14	8	8
Transverse diameter at the same place	17	12	9

To this species M. de Grossouvre ("Recherches sur la craie supérieure," pt. 2, fasc. 2, 1901, pp. 796 and 801) refers the unique specimen which M. Janet described and figured in the same paper (ibid., pp. 719, 720, pl. xiv, fig. 4, and text-fig. 1) as *Actinocamax Toucasi*, the two forms being, according to M. de Grossouvre, extreme modifications of the same type and connected by a number of intermediate links. The dimensions of the holotype of M. Janet's *A. Toucasi* are:—Length, 90 mm.; dorso-ventral diameter at the most inflated part, 12 mm.; transverse diameter at the most inflated part, 17 mm.; dorso-ventral diameter at the narrowest part at the alveolar extremity, 5 mm.; transverse diameter at the same place, 6 mm. Both forms occur at the same horizon as *Actinocamax granulatus* and *Actinocamax verus*; in France in strata which French authors regard as Upper Santonian and Lower Campanian (M. de Grossouvre, loc. cit.). It is interesting to note that two similar modifications of this species have been recorded (as *Actinocamax*

specimen bears some resemblance to that author's figures *3a*, *b*, but it is less inflated posteriorly and tapers less rapidly anteriorly than

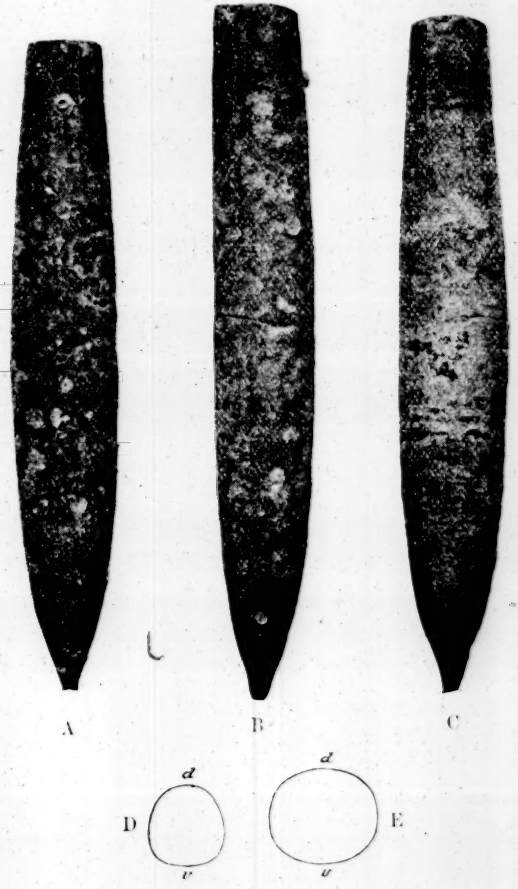


FIG. 1.—ACTINOCAMAX BLACKMOREI, n.sp.
Upper Chalk (Senonian, base of zone of *Actinocamax quadratus*), West Harnham, Salisbury. (Dr. H. P. Blackmore coll.)

A.—Ventral aspect.
B.—Right lateral aspect, showing the flatness of the dorsal surface and the slight inflation of the ventral surface.
C.—Dorsal aspect, showing the dorso-lateral grooves.
D.—Sectional view of alveolar end: *d*, dorsal; *v*, ventral.
E.—Transverse section at the most inflated part of the guard: *d*, dorsal; *v*, ventral.
All the figures are of about the natural size.

depressus [= *A. Grossouvrei*] and *A. depressus*, var. *fusiformis* [= *A. Toucasi*]) associated together in the Cretaceous rocks in the north of Germany (Professor Dr. A. Andreae, "Ein neuer *Actinocamax* aus der Quadratenkreide von Braunschweig": Mittheil. aus dem Roemer-Museum Hildesheim, No. 2, Dec., 1885).

the original of those figures; the compressed form of the alveolar end of the present example serves, however, to distinguish it from *Actinocamax Grossouvrei*. The fossil appears to be intermediate between *Actinocamax Alfridi* and *Actinocamax Grossouvrei*, but it does not appear to be identical with any described form of the genus. The present writer has therefore great pleasure in naming the species after Dr. H. P. Blackmore, F.G.S., of Salisbury.

Horizon and locality.—Dr. Blackmore's specimen was obtained from the chalk-pit at West Harnham, near Salisbury, at the base of the zone of *Actinocamax quadratus*. It is from a somewhat higher horizon than the Gravesend specimen which is described below.

ACTINOCAMAX sp.

Description.—The specimen (Fig. 2) consists of about two-thirds of the length of the guard, the posterior third being entirely wanting.

The anterior end is much fractured, especially on the ventral side, so that there is no trace of a ventral fissure if such existed, but a small piece of the dorsal part of the alveolar border is preserved; this seems to show that originally the alveolar end was only slightly excavated; before being imbedded in the chalk mud, however, this end was somewhat deeply excavated, but this excavation evidently did not form part of the original alveolar end, as is clearly shown by the angle at which the side of this cavity meets the small piece of the smooth original alveolar surface which is preserved. The sides of this cavity are also very irregular and covered with small pyramidal masses of a fibrous crystalline material (calcite), so that it is quite clear that they did not constitute the sides of the alveolus,[1] these latter being smooth and having precisely the same angle of inclination as the sides of the phragmocone. Nor does the cavity appear to have been that not infrequently produced in some forms of *Actinocamax* owing to the decay, after the death of the animal, of the uncalcified portion of the guard immediately surrounding the phragmocone.[2] Doubtless the central portion of this end of the guard was very imperfectly calcified, and was therefore easily disintegrated after the guard became detached from the animal. That the guard was exposed to the action of the sea for some time after the death of the creature is clear from the numerous sponge-borings by which it is traversed. Owing to the fractured condition of the anterior end, the dimensions of this part of the guard can best be taken at about 10 mm. below the alveolar border; here the transverse section of the guard is oval, the ventro-dorsal and transverse diameters being 12 and 10·5 mm. respectively, and the greatest width at a distance of about one-third of the ventro-dorsal diameter from the ventral surface.

[1] The term 'alveolus' is frequently somewhat loosely applied. The 'alveolus' is really the conical cavity at the proximal end of the guard of a typical Belemnite in which the phragmocone fits. Usually, however, in the genus *Actinocamax* the portion of the guard immediately in contact with the sides of the phragmocone was not calcified, and during fossilisation was destroyed; when, therefore, a conical cavity is preserved in the genus its sides are not those of the 'alveolus,' but those of a cavity having a greater angle than the 'alveolus.'

[2] See figures of the alveolar end of various forms of *Actinocamax* in the Geol. Mag., 1904, p. 409.

The posterior end is abruptly truncated at right angles to the axis of the guard, its ventro-dorsal and transverse diameters being 10 and 12·5 mm. respectively. The most inflated part of the guard is at a distance of 54 mm. from the alveolar extremity, and therefore only about 16 mm. from the posterior truncated end; the ventro-dorsal and transverse diameters here are 12 and 13·5 mm. respectively. It will thus be seen that in a ventral aspect the fossil has its greatest diameter at a point about three-fourths of its length from the alveolar end, and that from this point it tapers rather rapidly towards the alveolar end, but in the opposite direction only very slightly between this point and its posterior truncated end; whilst in a lateral aspect the dorsal and ventral surfaces are as nearly as possible parallel to each other. Anteriorly the fossil is compressed, whilst posteriorly it is depressed. The dorso-lateral grooves are well marked, and at about 6 mm. below the alveolar border are only about 3 mm. apart; in passing backwards they separate rather rapidly from each other until reaching the most inflated part of the guard, when they converge slightly over the rest of the specimen. Anteriorly each groove is flattened, broad, with its lateral boundary obscurely defined, and decreases in width rather rapidly until reaching the most inflated part of the guard, where it becomes relatively narrow (about 2 mm. wide) and parallel-sided. The ventral surface of the posterior half of the guard is flattened. The surface of the guard is smooth, but on the ventral portion of the most inflated part of the guard it is somewhat uneven, suggesting that here there is a slight deformation.

Certain grooves and sharply-incised lines near the posterior end of the guard are evidently the marks of injury. Thus, on the ventral surface and towards the right side (see Fig. 2, A), and having its median line about 4 mm. from the posterior end, there is a transverse roughened groove about 7 mm. long and 4 mm. wide, as if produced by a serrated edge. Also, on the right side and near the dorsal surface, there is another similar groove (see Fig. 2, D), about 7 mm. long, 2 mm. wide, and 2 mm. from the posterior end, whilst at some 3 mm. above this there is a shallower and much less regular groove of about the same length. Again, on the left side (see Fig. 2, C) and near the dorsal area, the surface extending upwards from almost close to the posterior fractured end for a distance of about 11 mm., and over a width of about 10 mm., bears a number of short, irregular, finely-incised lines.

As already stated, the fossil is imperfect at each end; the fracture at the alveolar end is comparatively recent, and was probably produced during, or possibly subsequent to, the extraction of the specimen from the rock. The fracture at the posterior end seems, however, to have been produced before the specimen was imbedded in the chalk, and most probably at the death of the animal. The marks near the posterior end that have been alluded to above seem to have been caused by the teeth of some animal, an enemy of the Belemnite, the saw-like cuts being produced by two adjacent teeth, and the sharply-incised lines by the point of the tooth placed in opposition to these two, for it is to be observed that the sharply-incised lines are as nearly as possible opposite the space between the two series of jagged

saw-like cuts. As these marks are not quite at the extremity of the specimen, the guard does not appear to have been bitten through, but rather to have broken off short during the Belemnite's struggles to escape. That the animal did not long survive the injury seems evident from the fact that the edges of the fractured surface are still fairly sharp; had the creature lived long after the guard was fractured these edges would doubtless have been more or less rounded off by the more or less enveloping mantle.

Measurements.

	mm.
Length	70+
Dorso-ventral diameter at the most inflated part	12
Transverse diameter at ditto	13·5
Dorso-ventral diameter near anterior end ...	12
Transverse diameter near ditto	10·5

Affinities and differences.—In a dorsal aspect the specimen agrees fairly well with M. Janet's figure (fig. 5*a*) of the dorsal surface of *Actinocamax Alfridi*,[1] but in a lateral aspect the dorsal and ventral surfaces are much more nearly parallel than are indicated in that author's fig. 5*c*. Again, the transverse section at the most inflated part of the guard is markedly depressed and not so nearly circular as in *Actinocamax Alfridi*. The depressed form of the transverse section of the posterior part of the guard agrees more closely with M. Janet's figures of *Actinocamax Grossouvrei*,[2] but the guard in that species is not so lanceolate, and has its anterior end depressed instead of compressed; further, in a lateral aspect its alveolar end tapers much more rapidly than that of the present specimen. Like the form described above, the present specimen seems to be intermediate between *Actinocamax Alfridi* and *A. Grossouvrei*; and it also is not identical with any described form of the genus known to the present writer. Compared with *Actinocamax Blackmorei* described above, the present example exhibits several differences, which may or may not prove to be of importance. The specimen is more slender, and when viewed ventrally is relatively less inflated at its broadest part; its ventral surface is flatter; the transverse section at its broadest part is relatively more depressed; and, in a lateral view, this specimen tapers evenly and slowly from the anterior end backwards, whilst in the same aspect *A. Blackmorei* is a little inflated at about the middle of the guard. Owing to its imperfection the writer, however, has not ventured to name this fossil.

Horizon and locality.—This specimen was obtained by Mr. G. E. Dibley, F.G.S., from the *Micraster cor-anguinum* zone of the Chalk in Messrs. Fletcher & Co.'s pit at Gravesend. It is the specimen which, in his paper "On the Zonal Features of the Chalk-pits in the Rochester, Gravesend, and Croydon Areas," Mr. Dibley records[3] from this pit as *Actinocamax*, n.sp.; amongst other fossils recorded from the same pit being *Actinocamax verus* and *Actinocamax Mercei*

[1] Bull. Soc. géol. France, sér. III, tom. xix, No. 9 (Nov., 1891), pp. 720, 721, pl. xiv, fig. 5, and text-fig. 4.

[2] Ibid., pp. 716–719, pl. xiv, figs. 1–3, and text-figs. 2, 3.

[3] Proc. Geol. Assoc., vol. xvi, pt. 9 (August, 1900), p. 495.

[= *Actinocamax granulatus*]. Thus from the list of associated fossils it will be seen that this specimen occurs at the same horizon as *Actinocamax Grossouvrei*.

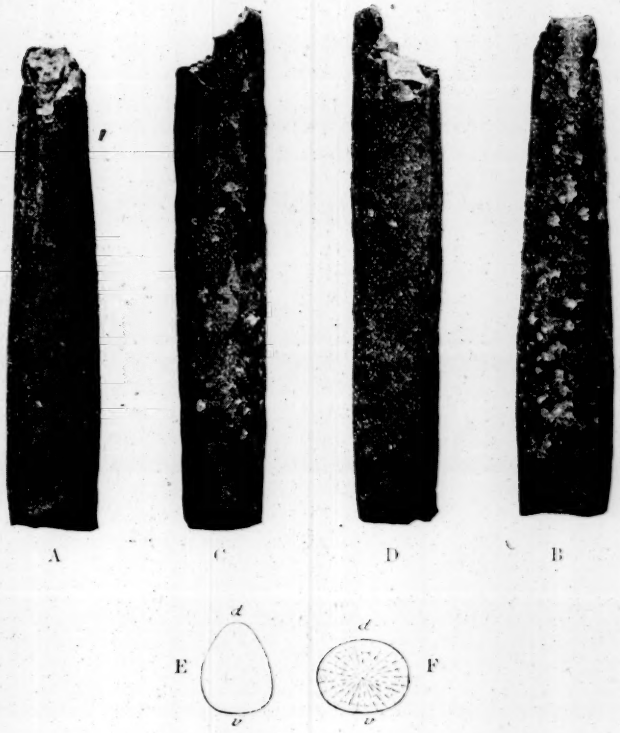


FIG. 2.—ACTINOCAMAX sp.

Upper Chalk (Senonian, zone of *Micraster cor-anguinum*), Gravesend, Kent. (British Museum collection, register number C. 10576.)

A.—Ventral aspect, showing one of the jagged saw-like cuts near the posterior end.

B.—Dorsal aspect, showing the dorso-lateral grooves, and very imperfectly near the posterior end two jagged saw-like cuts on the right. There are a number of irregular sharply-incised lines on the left near the posterior end, but these do not appear in the Figure.

C.—Left lateral aspect. The irregular sharply-incised lines near the posterior end seen in this view are scarcely visible in the Figure.

D.—Right lateral aspect, showing jagged saw-like cuts near the posterior end, two on the left and one on the right.

E.—View of the truncated posterior end: *d*, dorsal; *v*, ventral.

F.—Sectional view near alveolar end: *d*, dorsal; *v*, ventral.

All the figures are of about the natural size.

III.—Sedgwick Museum Notes.

A New Species of *Lichas*.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XVII.)

Lichas (Homolichas) melmerbiensis, sp. nov.

IT is rarely the case that we find complete individuals of any species of *Lichas*, especially in the Ordovician rocks, but several entire specimens belonging to a new British species have been recently collected by Mr. V. M. Turnbull from the Dufton Shales near Melmerby, and detached head shields, pygidia, and hypostomes from the same locality and horizon are not uncommon. Since most species of *Lichas* have been founded on detached and isolated portions of the body, it is desirable to give a somewhat full description of this new form, which belongs to a group of the genus not previously recognised with certainty in the British Isles.

Description.—Body oval, flattened, narrowing somewhat posteriorly, about two-thirds as wide as long. Head-shield broadly transverse and semilunate, measuring about 2½ times as wide as long; lateral angles produced backwards and overlapping outer portions of the first 4 or 5 thoracic pleuræ; median portion of head-shield projecting abruptly, interrupting regularity of anterior curved outline at anterior lateral angles of glabella.

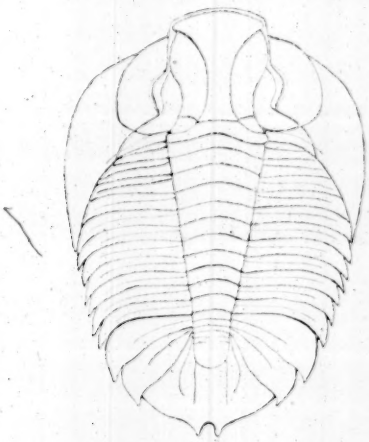
Glabella, fixed cheeks, and inner portion of free cheeks form prominent swollen central mass, raised high above flattened outer portion of free cheeks, which are much produced backwards into large pointed genal angles and extend nearly to the middle of the thorax.

Glabella somewhat oblong in shape, rather longer than wide, the axial furrows being subparallel with a slight outward concavity. The glabella is curved down more or less strongly in front of its middle, but is flattened from side to side. It consists of a median lobe with a long narrow neck, and is completely defined by the backward prolongation of the first lateral furrows to the occipital furrow, as in typical members of the section *Homolichas*. The median lobe has a frontal width equal to more than twice the width of the neck, and the triangular lateral angles completely extend in front of and overlap the anterior ends of the tricomposite lateral lobes. A slight widening of the neck of the median lobe takes place towards its base, owing to the divergence posteriorly of the prolonged first lateral furrows, but the median portion of the neck has nearly parallel sides.

Tricomposite lateral lobes elongated-oval, somewhat pointed anteriorly, slightly curved outwards in front and less so at their base, towards which they narrow a little, but their axes are nearly parallel. Their base is rather abruptly truncated by the strong furrows which cut off the pair of rather large triangular or subrhomboidal occipital lobes, and are regarded as the displaced lateral portions of the occipital furrow. These occipital lobes are completely circumscribed, but are rather less swollen than the lateral lobes of the glabella.

First lateral furrows of uniform strength for their whole length and completely marking off the median lobe of the glabella; they converge at first strongly inwards, then curve backwards and run almost parallel on each side of the neck, curving again a little outwards before meeting the occipital furrow, which they do at an angle of about 70° or rather less. The axial furrows curve gently outwards round the front end of the lateral lobes, then bend slightly inwards, describing a weak concave curve in their course to the occipital lobes, outside which they bend strongly outwards.

The occipital furrow consists of a median straight portion at the base of the median lobe of the glabella, and the paired lateral portions displaced rather forwards, which enter the axial furrow at right angles. The occipital ring is broad, flattened, and somewhat arched forwards, with the two oblique lateral furrows cutting off the occipital lobes; there is no distinct median tubercle.



Restored outline figure of *Lichas* (*Homalichas*) *melmerbiensis*, sp. nov.:
Dutton Shales, near Melmerby.

Fixed cheeks small, reniform, convex, about half the length of the glabella, and about two-thirds the width of the lateral lobes, along which they extend to a point rather in front of their middle. The posterior part of the fixed cheek bends strongly outwards behind the eye, and extends for less than half the distance between the axial furrow and the lateral margin of the head-shield. The eye-lobe is flattened and separated off by a distinct shallow furrow, which is weakly angulated in the middle.

Free cheeks consisting of an inner swollen portion, which rises up suddenly almost to the level of the glabella and nearly overhangs the front margin, and of an outer lateral portion, which is depressed, weakly convex, and triangular, and is prolonged backwards into the large pointed genal angles. Eyes semilunate, narrow, about one-third the length of the glabella, and are supported on the swollen portion of free cheeks.

The head-shield is ornamented with rather widely spaced, round tubercles, of moderate and fairly uniform size, between which are scattered smaller secondary and tertiary ones without any regular arrangement and usually at some distance apart.

Thorax of eleven segments, not decreasing much in width posteriorly. The axis, however, which is strongly convex and prominent, is conical in shape, tapering rather rapidly towards the pygidium to half its anterior diameter. The ornamentation of the axis consists of small sharp tubercles of fairly equal size, not closely placed nor regularly disposed, with a few smaller ones interspersed. The axial furrows are strong.

The pleuræ are of uniform size and overlap slightly; their inner half is arched up gently, while their outer half bends down slightly and curves backward to end in a falcate point. Each pleura bears on its feebly convex surface a well-marked submedian and slightly diagonal furrow, which dies out shortly before reaching the point. The tubercles, which are like those on the axis, are usually arranged in a single row of widely spaced primary ones alternating with a double row of secondary or tertiary ones along each side of the diagonal furrow.

Pygidium of rather a transverse shape, not quite twice as broad as long, with a convex axis of less than one-fourth the total width and lateral lobes composed of two pairs of complete pleuræ ending in free marginal points, and of one incomplete pair followed by a median postaxial piece. The ends of the third pair of pleuræ form a pair of short blunt projections, closely placed, and give a bifurcate posterior termination to the pygidium. The axis is prominent, convex, and subcylindrical; the strong axial furrows scarcely converge at all posteriorly and are prolonged with undiminished strength nearly as far behind it, but do not reach the posterior margin. The axis extends for about half the length of the pygidium, and its convexity is continued into the anterior portion of the post-axial piece, dying out rather suddenly. A weak curved furrow (sometimes interrupted in the middle) crosses over this median convexity and defines the axis behind, the axial furrows bending in slightly at this point on each side. There are 2 to 3 complete well-marked rings on the front end of the axis followed by traces of 1 to 2 fainter incomplete rings. Each pleura of the first pair on the lateral lobes has a subfalcate shape and is curved gently backwards beyond the weak fulcrum, ending in a short free recurved point; a submedian diagonal furrow traverses about two-thirds of its length, and is inclined at about 15° to the front edge of the pygidium.

The second pleura is separated from the first by a slightly sinuous furrow nearly parallel to the diagonal furrow of the first pleura. This pleura is more leaf-shaped and has a narrow base; its end forms a short recurved free point like the first, and its surface bears a diagonal furrow nearer the anterior than the posterior margin of the pleura and parallel to the first interpleural furrow. The interpleural furrow between the second and third pleura makes an angle of about 45° with the axial furrow. As stated above, the third pleura is incomplete, not being marked off from the post-axial piece by

a complete furrow to the margin. This pleura is broad and triangular, and bears a submedian furrow on its surface curving round inwards towards the prolongation of the axial furrow, but dying out before reaching it. Half the side of the pygidium is formed by the margin from the second pleura to the point of the third pleura, and it is weakly sigmoidal, bending at first outwards and then inwards. The points of the third pair of pleuræ are somewhat closely placed, and the margin between them is rather deeply emarginate. The post-axial piece is nearly as wide as the axis, is flattened, and bears no furrow. The tuberculation of the pygidium is similar to that of the thorax, but the tubercles show no regularity of distribution on the pleuræ, and the general surface of the lateral lobes seems to be also very finely granulose.

The hypostome associated with this *Lichas* and most probably belonging to it has a strongly arched anterior outline and a deeply and broadly emarginate wide posterior border, but only the body is well preserved in any case. The body is rounded-subquadrate, moderately convex, rather broader than long; anteriorly it has a strongly arched outline, but its sides are subparallel, and its posterior end is abruptly truncated nearly at right angles and almost straight. The lateral middle furrows form a pair of simple broad, short, rather oblique notches in its sides at about two-thirds its length, and do not fork.

Dimensions:

	I.	II.	III.	IV.	V.
Length of whole individual	31·75	30·00	—	—	—
Length of head	9·50	9·00	—	—	—
Width of ditto	27·00	27·00	—	—	—
Width of glabella at base	7·25	—	—	—	—
Length of thorax	13·25	11·75	12·00	—	—
Width of thoracic axis at front end...	9·00	8·00	7·75	—	—
Length of pygidium	9·00	9·00	8·50	15·5	—
Width of ditto	20·50	20·00	16·00	26·0	—
Width of axis of ditto	4·00	4·00	3·50	6·0	—
Length of hypostome	—	—	—	—	11·25
Length of body of ditto	—	—	—	—	6·75

Affinities.—The general characters of the head-shield ally this form very closely to *L. angusta*, Beyr.,[1] which Schmidt says is distinguished from *L. deflexa*,[2] Sjogr., by the glabella being less swollen and the median lobe less transversely expanded in front. The pygidium of *L. angusta*, so far as it is known, agrees more with *L. Eichwaldi*, according to Schmidt, than with our specimens. The latter resemble in this part *L. deflexa*, which has the points of the third pair of pleuræ on the lateral lobes similarly projecting; but in ours these points are closer together, the whole pygidium is less transverse, the second pair of pleuræ do not extend so far back, and the diagonal furrows of the third pair do not unite with the axial furrows. The hypostome of *L. angusta* seems to be practically identical, so far as ours is known.

[1] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. ii (1885), p. 108, t. iv, figs. 18–23.

[2] Ibid., p. 101, t. iv, figs. 24–35.

L. Eichwaldi, Nieszk.,[1] and *L. Pahleni*, Schmidt,[2] are also closely allied to our Melmerby form.

In *L. Eichwaldi* the inner portion of the free cheeks is similarly swollen and the outer portion depressed, and the median portion of the head-shield projects in the same manner; but the pygidium has no freely projecting points to the pleurae.

L. Pahleni has straighter axial furrows bounding the glabella, and the pygidium is more elongated. The latter species is found in D_1 in the Baltic provinces, and the former in E.

L. augusta occurs in F_1 and F_2, and *L. deflexa* in D_2.

From the above comparison it will be seen that our Melmerby form does not completely agree with any of these species, though it shows so many points of affinity with all, and it appears necessary to regard it as a new species which may be suitably named *melaerbiensis*. The section to which it belongs is that termed *Homolichas* by Schmidt[3] and the author,[4] and in the latter's scheme of classification it lies in the second main division of the whole genus *Lichas*.

EXPLANATION OF PLATE XVII.

Fig. 1. *Lichas* (*Homolichas*) *melaerbiensis*, sp. nov. Complete individual. × 2. Dutton Slades, near Melmerby.
,, 2. Ditto. Ditto. × 2.
,, 3. Ditto. Thorax and imperfect pygidium. × 2.
,, 3*a*. Ditto. Thoracic segment enlarged to show ornamentation. × 5.
,, 4. Ditto. Posterior portion of middle part of head-shield. × 2.
,, 5. Ditto. Anterior portion of glabella. × 1½.
,, 6. Ditto. Pygidium. × 2.
,, 7. Ditto. Hypostome. × 2½.

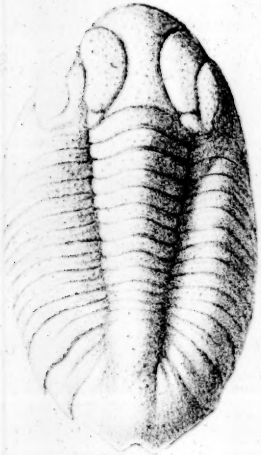
IV.—On the genus *Pygocephalus* (Huxley), a primitive Schizopod Crustacean, from the Coal-Measures.

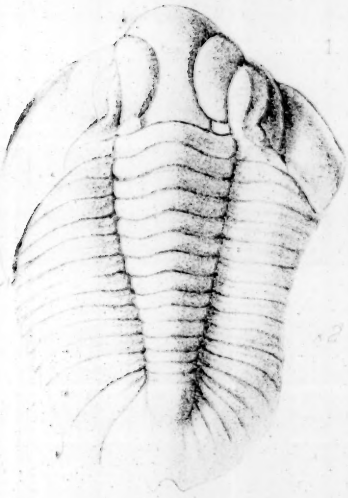
By Henry Woodward, LL.D., F.R.S., V.P.Z.S., F.G.S.

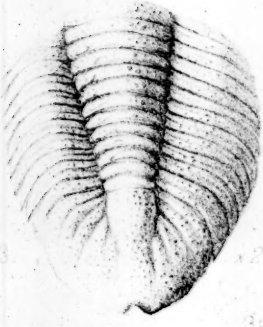
(PLATE XVIII.)

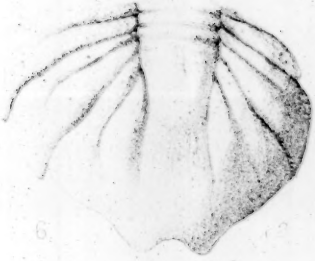
Pygocephalus cooperi was first described by Professor Huxley from the Coal-measures of Paisley in 1857 (Quart. Journ. Geol. Soc., vol. xiii, pp. 363–369, pl. xiii), and a second specimen by the same author in 1862 (op. cit., vol. xviii, pp. 420–422, text-figure). Some additional specimens came into my hands for examination, and were communicated to the Glasgow Geological Society in 1866 (Trans. Geol. Soc. Glasgow, vol. ii, pp. 234–247, pl. iii, figs. 1–3). In that paper I described a second species, which I named *Pygocephalus Huxleyi* (text-figure, p. 244, op. cit.). The specimens referred to above were obtained from the Coal-measures of Paisley, from Kilmaurs, and from near Manchester. Since then the late Mr. Henry Johnson, F.G.S., formerly of Dudley, obtained

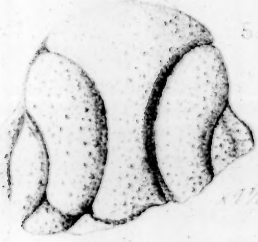
[1] Schmidt: op. cit., p. 104, t. iv, figs. 10–17.
[2] Schmidt: op. cit., p. 97, t. iv, figs. 6–8.
[3] Schmidt: op. cit., pp. 31, 40, 42.
[4] Reed: Q.J.G.S., vol. lviii (1902), p. 78.











W.M. Woodward del. et lith. West, Newman imp.

Lichas (Homalichas) melmerensis sp. nov.
Dufton Shales near Melmerby.

many examples of *Pygocephalus* from the Clay-ironstone nodules of Coal-measure age at Coseley, near Dudley, now in the Geological Department of the British Museum (Natural History Branch), Cromwell Road, S.W. These specimens are preserved in great perfection, and I had fully intended to figure them some years ago, but the pressure of other work caused them to be set aside for a time. Last year I received an example of *Pygocephalus* from Mr. Walter Baldwin, F.G.S., obtained from the Clay-ironstone of the Middle Coal-measures at Sparth, Rochdale (for description see Fig. 4, p. 405). I have also received through Mr. H. A. Allen, F.G.S., of the Geological Survey Museum, Jermyn Street, by the kindness of their owner, Mr. Herbert Hughes, Assoc. R.S.M., F.G.S., of Horseley House, Wolverhampton Street, Dudley, four most interesting specimens of *Pygocephalus* collected by him, two of which prove to be females,[1] a point of extreme interest not heretofore observed.

In his original paper (Quart. Journ. Geol. Soc., 1857, pp. 363–364, pl. xiii) Professor Huxley gave a very complete description of the underside in the male of *Pygocephalus Cooperi*, and, in the figures accompanying his paper, he shows the hexagonal plates forming the sternites of the thoracic segments; to the lateral marginal plates are attached the coxopodites of the thoracic limbs (pereiopods). He had also determined the presence of a distinct endopodite and exopodite to each thoracic limb. He writes as follows (p. 365):—"Attached to the outer boundaries of the lateral (ventral) plates, seven appendages are observable on one side and six on the other. In the more perfectly preserved appendages (fig. 1*c*) there may be distinguished a short, proximal, convex, subcylindrical joint, followed by at least three other slender and delicate articulations; of these the proximal one is the longest, the terminal next in length, and the middle one shortest. The terminal joint exhibits indications of further subdivision.

"The fifth limb on the right side presents a very important character, inasmuch as there lies parallel with and behind it a delicate, curved, many-jointed filament (fig. 1*c*), which externally abuts against the terminal joint of the appendage, and internally lies parallel with the longer cylindrical joint, and in close contiguity with the basal division of the appendage. I believe, in fact, that this filament is nothing less than the outer division of the appendage, or its exopodite; and I am inclined to think that traces of a corresponding filament are visible in some of the other appendages." On p. 367 he concludes further that "the small internal pair of appendages are the antennules, the large external ones antennæ; the seven segments are the sterna of seven thoracic somites, increasing in width from before backwards; the narrow longitudinal plates (lying outside the margin of the thoracic sternites) are the edges of a short carapace; and the semicircular disk is the

[1] Since penning the above I have discovered two imperfectly preserved females of *Pygocephale* amongst Mr. Henry Johnson's specimens (registered number I. 1536) from Coseley, near Dudley, to be presently referred to again.

termination of a large abdomen bent upon itself with the telson and uropods more or less flattened and crushed."

Professor Huxley then compares *Pygocephalus* with *Mysis*, the 'opossum-shrimp' of our own seas:—"In *Mysis*, as in *Pygocephalus*, the abdomen is very large, as compared with the thorax, and the carapace is short and delicate. The antennules present two subcylindrical basal joints; the antennæ have two large basal joints giving attachment to a large scale externally and superiorly, while internally the fusiform base of the internal division of the antennæ is formed by three joints, with the last of which a very long multiarticulate filament is continuous" (see Plate XVIII).

"There are seven pairs of conspicuous thoracic members in *Mysis*, the first pair of thoracic appendages being smaller than the others, and applied against the mouth; so, also, there are seven pairs of appendages in *Pygocephalus*," but the oral appendages in the fossil cannot be accurately determined.

"In *Mysis*, again, the thoracic limbs are short and feeble, and consist of two parts, an endopodite and exopodite, the latter being terminated by a many-jointed filament. They present the same peculiarities in *Pygocephalus*" (Pl. XVIII, Figs. 2, 9).

"In *Mysis* the sterna of the thoracic somites are well developed, and gradually increase in width from before backwards; so do those of *Pygocephalus*."

"The abdomen in *Pygocephalus* is much thicker and stronger in proportion than is that of *Mysis*"; and as seen from the drawings by Mr. Searle of the later specimens obtained, the telson, together with the three-jointed and paired uropods, on either side, differ greatly in form from those of *Mysis*, being far wider, more nearly resembling some of the Coal-measure Palæmonidæ figured by Dr. B. N. Peach, F.R.S.[1] This agrees with our experience concerning all these earlier forms of Crustacea, that they are *less specialized* in structure than are those of our modern times.

Huxley concludes that *Pygocephalus* is either a lowly form of Decapod or one of the Stomapoda, and he adds in a note, "the Schizopoda, including *Mysis*, are not essentially different from the Decapoda."

The result of our examination of the fine series of specimens of the male of *Pygocephalus*, obtained since 1857 for the British Museum (Natural History), tends not only to expand and perfect Professor Huxley's original description, but to prove the great accuracy of his observations of fifty years ago.

The additional specimens lately received from Mr. Herbert Hughes, obtained from the same bed of clay-ironstone nodules at Coseley, near Dudley, which formerly proved so prolific under the labours of the late Mr. Henry Johnson, have yielded clear evidence of the female of *Pygocephalus*. Those which are illustrated upon our Pl. XVIII, Figs. 5 and 6 show most distinctly the presence of a brood-pouch or marsupium on the ventral aspect of the thorax. Such structures are well known in many recent Crustacea, but have not hitherto been preserved in any fossil form.

[1] See Trans. Roy. Soc. Edinb., vol. xxx (1888), pls. 8–10.

Dr. W. T. Calman, of the British Museum (Natural History), who has devoted himself for many years to the study of the Crustacea, has given special attention to these structures, and finds in them a valuable aid to the classification of the Crustacea. In a paper published in 1904[1] he wrote as follows (p. 150 op. cit.):—"Among the characters in which the Mysidacea differ from the Euphausiacea and agree with the Edriophthalmate orders, the most conspicuous is the possession by the female sex of a *brood-pouch*, or *marsupium*, in which the eggs and young are carried. It cannot be doubted that this structure is homologous throughout the whole series which I have named from this feature, the Peracarida,[2] in spite of real or alleged differences in the mode of its development. It is formed by a series of overlapping plates (which Claus considers with great probability to be of the nature of epipodites) attached to the inner side of the coxopodites of some or all of the thoracic limbs.

"When, as in many Isopoda, the coxopodites are fused with the body, the plates are attached to the sternal surface of the somites. In some cases these plates (or '*oostegites*') develop as bud-like outgrowths from the bases of the limbs, increasing in size at successive ecdyses as sexual maturity is approached; but in certain Isopoda it has been shown that the course of development is abbreviated, the 'oostegites' growing in the space between the sternal cuticle and the hypodermis, and being set free completely formed at a single moult."[3]

"Probably some similar process has given rise to the statement that the oostegites arise by splitting of the ventral cuticle in the Cumacea[4] and in the Isopod *Gnathia*.[5] At the same time it is certain that the formation of the brood-pouch is profoundly modified in certain parasitic Isopods of the tribe Epicaridea. In many of these the 'oostegites' develop in the typical fashion just described, but in the more specialized forms the structure is very different and hard to understand.

"In *Hemioniscus*, where the development has been worked out in detail by Caullery & Mesnil,[6] the marsupial cavity is hollowed out in a thickening of the ectoderm on the sternal surface, and is from the first completely closed. Further research will be required to show what relation this cavity bears to the normal marsupium."

"Apart from such exceptional cases, however, the possession of oostegites is a character quite peculiar to the group of orders included in the Peracarida and not found in any other Crustacea. It is true that the Euphausiidæ are described as carrying their eggs in sacs attached to the sternal surface of the thorax, and it has been assumed

[1] "On the Classification of the Crustacea Malacostraca," by W. T. Calman, D.Sc.: Ann. & Mag. Nat. Hist., ser. VII, vol. xiii (1904), pp. 144–158.

[2] From πήρα, *pera*, a pouch, and *carida*, a shrimp.

[3] Cf. Leichmann, "Beitr. z. Naturgesch. d. Isopoden": Bibl. Zool., x (1891).

[4] G. O. Sars, "Beskr. af de paa Fregt. Josephines Exp. fundne Cumaceer": Kongl. Svenska Vet.-Akad. Handl., ix, 13 (1871), p. 19.

[5] Dohrn, "Entw. und Organ. v. *Praniza* (*Anceus*) *maxillaris*": Zeitsch. f. wiss. Zool., xx (1870), p. 70.

[6] "Recherches sur l'*Hemioniscus balani*, Buchholz . . . . .": Bull. Sci. France et Belgique, xxxiv (1901), pp. 316–362, pls. xvii, xviii, 5 figs. in text.

that these represent the marsupium of the Mysidacea. But Sars has pointed out that the 'ovisacs' are apparently formed by the consolidation of some cementing substance which is extruded along with the eggs from the oviducts."

Beneath I have given the classification proposed by Dr. W. T. Calman for Crustacea of the sub-class Malacostraca :—

Series **Leptostraca**, Claus, 1880.

Division PHYLLOCARIDA, Packard, 1879.

Order NEBALIACEA, nov. nom.

Series **Eumalacostraca**, Grobben, 1892.

Division SYNCARIDA, Packard, 1886.

Order ANASPIDACEA, nov. nom.

Division PERACARIDA, nov. nom.

Orders MYSIDACEA.
CUMACEA.
TANAIDACEA.
ISOPODA.
AMPHIPODA.

Division EUCARIDA, nov. nom.

Orders EUPHAUSIACEA.
DECAPODA.

Division HOPLOCARIDA, nov. nom.

Order STOMATOPODA.

Dr. Calman gives the following diagnosis of his proposed division Peracarida :—Carapace, when present, leaving at least four of the thoracic somites distinct. First thoracic somite always fused with the head. Antennal protopodite typically of three segments. Mandible with lacinia mobilis (except in parasitic and other modified forms). Thoracic limbs flexed between fifth and sixth segments. 'Oostegites' attached to some or all of the thoracic limbs in female, forming a brood-pouch. No appendix interna on pleopods. Hepatic cæca few and simple. Heart elongated, extending through the greater part of the thoracic region, or displaced into abdomen. Spermatozoa filiform. Development taking place within the brood-pouch ; young set free at a late stage." (Ann. & Mag. Nat. Hist., ser. VII, vol. xiii (1904), pp. 156, 157.)

The following may serve as illustrations of the frequent occurrence and variation in form of the brood-pouch in living Crustacea of different orders included in Dr. Calman's division Peracarida.

In the family Lophogastridæ (see the Rev. T. R. R. Stebbing's History of Recent Crustacea, 1893, p. 256) the marsupium consists of seven pairs of plates, the young undergoing their metamorphosis within the egg. The same arrangement occurs in the Eucopiidæ (op. cit., p. 260).

In the Mysidæ the marsupium is composed of seven, or more often of only two or three, pairs of plates (op. cit., p. 267).

In the Cymothoidæ the female has five pairs of marsupial plates on the first five pairs of thoracic limbs, and small supplementary plates on the last two pairs (op. cit., p. 339). In this family the plates of

the marsupium are so imbricated that the last of the five pairs is outermost (op. cit., p. 394). In the Scroliidæ the marsupium consists of four pairs of plates (op. cit., p. 357) [formed probably between and set free by the separation of the ventral cuticle from the hypodermis]. In the Asellidæ the marsupial pouch is formed of plates pertaining to the first four, or to the second, third, and fourth segments of the thorax (op. cit., p. 376).

In the Dajidæ the first four pairs of imbricated plates form a movable lid to the front opening of the marsupium, the large fifth pair close it behind (op. cit., p. 398).

In the Entoniscidæ the marsupium is formed of five pairs of plates (op. cit., p. 405).

In one of the forms of parasitic Isopoda, of the family Bopyridæ (*Ione thoracica*), the imbricated plates of the brood-pouch in the female consist of seven pairs, and they closely resemble in form those of *Pygocephalus*, but they overlap one another in exactly the reverse order from back to front.[1]

There are other characters in the recent Peracarida which distinguish them from the Eucarida, in the structure of the mandibles and in certain characters presented by the thoracic limbs, but these we need not discuss here, as the fossil forms are not sufficiently delicately preserved, and cannot, of course, be dissected like recent specimens.

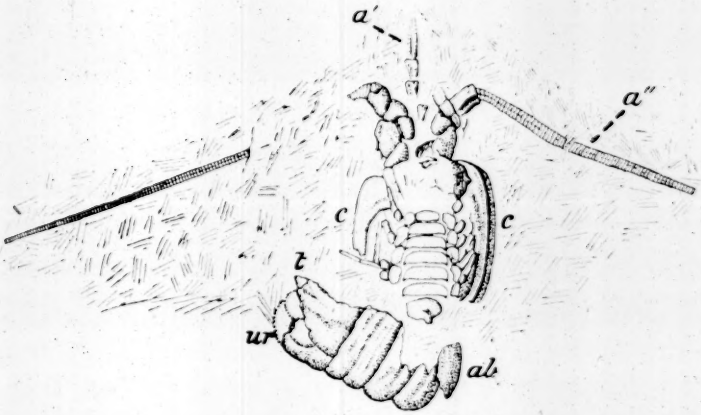


FIG. 1.—*Pygocephalus Cooperi*? (Huxley), from Coal-measures, Spath, near Rochdale. Presented by Mr. Walter Baldwin to the British Museum (Natural History). Length of antennæ, 50 mm.; length of thorax, 25 mm.; length of abdomen, 25 mm. *a'*, antennules; *a''*, antennæ; *c*, *c*, lateral border of carapace; *ab*, abdomen; *ur*, uropods; *t*, telson.

In addition to the two well-preserved examples of the female in Mr. Herbert W. Hughes' collection figured on our Plate (Figs. 5 and 6), I have detected two imperfectly preserved females in the Museum collection (I. 1536), part of the late Mr. Henry Johnson's collection which I had previously overlooked. They serve to confirm the evidence afforded by Mr. Hughes' more perfect specimens.

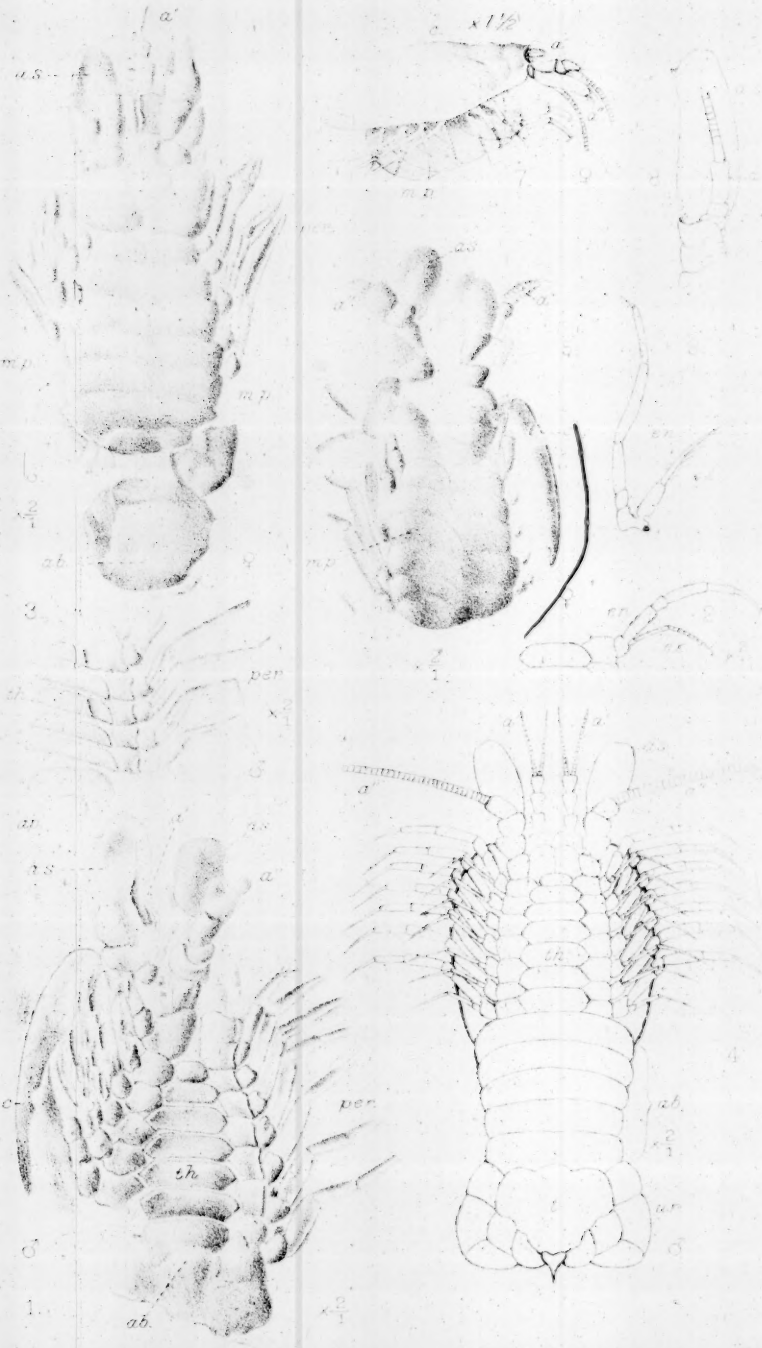
[1] Spence Bate & J. O. Westwood, "Sessile-eyed Crustacea," 1868, vol. ii. p. 255.

Measurements of the female of *Pygocephalus* (Fig. 6):—Extreme length of the more perfect female of *Pygocephalus*, 40 millimetres; breadth at base of antennæ, 10 mm.; breadth of caudal plates, where infolded towards base of thorax, 13 mm.; greatest breadth of *marsupium* near the centre of thorax, 12 mm.; breadth in front, 8 mm., posteriorly 10 mm.; number of imbricated plates, 7 pairs; length, 15 mm.; average length of plates, about 2 mm. The outer margins of the scales of brood-pouch are straight, the inner borders roundly curved. Measured along its convexity, length of abdomen in Mr. Johnson's specimen (I. 1836), 20 mm.; length of telson, 10 mm.; the margins of the 5 segments are recurved and their borders pointed.

In the male *Pygocephalus*, in which the oostegites are absent, the central thoracic plates are usually somewhat hexagonal in form; with these the small marginal plates (bearing the coxopodites of the thoracic limbs) are intercalated. In some examples of *Pygocephalus*

Fig. 2.—*Pygocephalus* (*Anthrapalæmon?*) *Parkeri*, sp. nov., H. Woodw. Coal-measures: Sparth, near Rochdale. Obtained by Mr. W. A. Parker, F.G.S., and presented to the British Museum (Natural History). × 2 nat. size.

the central plates are more quadrate-oblong. These differences may also be noticed in Huxley's figures of the thoracic plates of his two examples (Quart. Journ. Geol. Soc., 1857, pl. xiii, figs. 1*a*, 2, 3; also in our Plate XVIII, Fig. 3, and in Woodcut Fig. 1 in text). The telson and uropods in Huxley's example are represented as truncated (op. cit., pl. xiii, figs. 1*a*, *b*). The telson of those we figure now are pointed (see Pl. XVIII, Fig. 4). But possibly the caudal plates of Figs. 1 and 6 from Mr. Hughes' collection may have had a blunt and square telson with correspondingly



A. H. Searle del. et lith. West, Newman imp.

Pygocephalus Cooperi, Huxley. Coal-Measures
Coseley, near Dudley.

broad uropods. Further research may show that the adult female differs from the male not only in the possession of marsupial plates, but in the form of its caudal plates also.

Another specimen from Sparth, Rochdale, was referred to by me a year ago (Brit. Assoc. Reports York Meeting) under the manuscript name of *Anthrapalæmon Parkeri*, H. W., but examining this specimen more critically I think this Crustacean should be referred to *Pygocephalus*, not to *Anthrapalæmon*. If this view is correct it is the only example hitherto met with in which the entire dorsal aspect of the Crustacean lies exposed.

It differs from *Pygocephalus Cooperi* in having four small and one large serration on the latero-anterior angles of the carapace, but the telson and its uropodites agree exactly with *Pygocephalus*. The antennæ also bear a large oval scale as in *Pygocephalus*. Although my evidence is incomplete I venture to place this form in the genus *Pygocephalus*, with the trivial name of *Parkeri*, after its discoverer, Mr. Wm. Albert Parker, F.G.S., of Rochdale.

In conclusion, I wish to thank my friend Dr. Calman for the very kind advice and assistance which he has given me in this investigation, and for the trouble he took in examining the specimens showing marsupial plates in order to verify my interpretation of their true nature.

EXPLANATION OF PLATE XVIII.

PYGOCEPHALUS COOPERI, Huxley.

Coal-measures—Clay Ironstone; Coseley, near Dudley.

FIG. 1.—View of ventral aspect of male specimen, ♂.
a.s. antennal scale; *a'*, antenna; *a''*, antennule.
c. margin of carapace.
th. hexagonal thoracic plates (sternites).
per. series of thoracic limbs (pereiopods).
ab. abdomen flexed ventrally upon the thorax.

„ 2.—A single thoracic appendage (after Huxley) showing (*en.*) the endopodite and (*ex.*) the exopodite.

„ 3.—Part of another specimen of male *Pygocephalus*, ♂.
th. thoracic sternites somewhat displaced.
per. five of the thoracic limbs showing endopodite and exopodite.
a.p. doubtful (anal ?) plate displaced.

„ 4.—An attempted restoration of the male ♂ underside, showing the antennules (*a'*, *a''*); the antennæ (*a''*, *a'''*) with their long flagella and broad antennal scale (*a.s.*); the 7 thoracic sternites (*th.*) with corresponding paired pereiopods, each with exopodite and endopodite, the 5 abdominal plates (*a.b.*), followed by the telson (*t.*) with its two paired uropodites (*ur.*).

FIGS. 5 and 6.—Females of *Pygocephalus Cooperi*, showing 6 or 7 broad, scale-like, imbricated plates (*m.p.*), 'oostegites,' forming the marsupium in which the eggs and the immature young are carried. The other parts lettered are the same as in the male examples (Figs. 1, 3, 4).

FIG. 7.—Carapace with cephalo-thoracic appendages and marsupium (*m.p.*) of recent female Schizopod (*Eucopia australis*, Dana), copied from Challenger Report (Zoology), vol. xiii (Schizopoda), pl. ix, fig. 2. Enlarged about 1½ times nat. size.

„ 8.—Antennal scale (*a.s.*) with part of flagellum and basal joints of antenna of *Eucopia* from same plate as Fig. 7.

„ 9.—One of the legs of *Ceratolepis* showing endopodite and exopodite, copied from same volume of Challenger Report as Figs. 7 and 8 (op. cit., pl. i, fig. 14).

V.—Preliminary Note on Overthrust Structure at Langkofl in the Dolomites.

By Dr. Maria M. Ogilvie Gordon.

GEOLOGISTS who are familiar with the Dolomites of South Tyrol will know the transverse sections of Langkofl and Plattkofl Dolomite given by Geh. von Mojsisovics ("Dolomit-Riffe," 1879, pp. 191–204). Mojsisovics describes the Schlern Dolomite of Langkofl as resting conformably upon south-dipping Lower Muschelkalk and Werfen strata, and concludes that the Schlern Dolomite here represents a dolomitic facies of all the Mid-Triassic geological horizons—viz., the Mendola, Buchenstein, Wengen and Cassian horizons. The Lower Muschelkalk and Werfen strata then bend northward with a steep flexure and, according to Mojsisovics, conformably underlie the same Mid-Triassic series of Mendola, Buchenstein, Wengen, and Cassian horizons, but the Buchenstein horizon is here present in the nodular limestone facies, and the Wengen and Cassian horizons in their tufaceous facies.

In a paper which, I hope, may shortly be published, I have described the presence of two important thrust-planes, inclined southward, in the north wall of Langkofl and the adjacent hill-slopes on the north. One of these thrust-planes passes between the Schlern Dolomite of Langkofl and the group of Lower Muschelkalk and Werfen strata at its base. The Schlern Dolomite above the thrust-plane dips northward, the underthrust strata dip southward—rather more steeply than the thrust-plane which at the north wall has an average inclination of 15°–25° south-south-east.

The other thrust-plane is also inclined south-south-east and passes between the Werfen and Muschelkalk strata of the underthrust group and the Wengen lavas on the hill slopes adjacent to Langkofl on the north. For convenience, I have termed the segment of older Trias at the base of Langkofl the 'Montesora' segment.

Another thrust-plane inclined southward is present in the Plattkofl or south aspect of the Langkofl and Plattkofl group. The tufaceous and Cipit Limestone facies of Cassian strata in Fassa Joch dovetails towards the north with the dolomitic facies of the Cassian horizons in Plattkofl mountain. And a thrust-plane has carried the southern facies northward to some extent above the dolomitic facies.

I have farther shown that leading east-west eruptive fissures present on the north and south of the Langkofl and Plattkofl group in Mid-Triassic time were at that time undergoing depression relative to the intervening plateau upon which the calcareo-dolomitic deposits accumulated, and that simultaneously with the Mid-Triassic differential movements and eruptive invasions at east-west fractures a series of N.E.–S.W. flexures was in course of formation, the eruptive facies gaining ingress more especially in the troughs of that series.

My investigation of the Bufaure group of igneous mountains between Fassa and Contrin Valléys leads me to conclude that this was a depressed series of flexures in the course of both the east-west and N.E.–S.W. systems of plication, and was already broken in Mid-Triassic time by an intersecting network of fractures. The

igneous rocks of the area are essentially fissure accumulations of lava, continuous with a rim of marginal sills which had found entry amidst the indipping strata of the surrounding Mid-Triassic flexures.

The leading east-west eruptive fissure of Bufaure, and a parallel fissure at Rodella Hill on the north, may be traced continuously eastward to the Fedaja and Buchenstein district, and westward through the slopes of Duron Valley to Seiser Alpe. Both on the north and south margins—for example, at Plattkoff and Sasso Pitschi on the north margin, and at Mairin, Wand, Udai, Molignon, Rosszähne, and Schlern on the south margin—there is a rapid passage of all or part of the lavas and tuffs of the fissure facies into calcareo-dolomitic rocks of the same age. The still higher horizons of Schlern Dolomite can in some places, such as Pordoi in Sella Massive, be seen to give place to the "Schlern Plateau facies" of Raibl strata, which locally includes thin lavas, or to pass insensibly upward into well-stratified Raibl horizons of dolomite.

Round the west of the Seiser Alpe area, the Bufaure and Rodella east-west eruptive fissures become continuous with the leading east-west eruptive fissure which in Mid-Triassic time was active along the north of Seiser Alpe, the Langkoff and Sella Mountains, and the St. Cassian-in-Enneberg meadowland. This fissure is the "Pitzculatsch fault" in my Gröden Pass section (Q.J.G.S. 1899, vol. lv, pp. 567–569), and is that against which, subsequently to Mid-Triassic eras, the "Montesora segment" was pinched up between the fissure facies and the dolomitic.

The general conclusions which I draw from these observations will be fully set forth in the published paper, which will be accompanied by an illustrative series of parallel sections.

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: SEVENTY-SEVENTH ANNUAL GENERAL MEETING HELD AT LEICESTER, AUGUST 1ST, 1907.

I.—ADDRESS TO THE GEOLOGICAL SECTION. By Professor J. W. GREGORY, D.Sc., F.R.S., President of the Section.

I. *The Geological Society of London.*—1907! This is the centenary year of the Geological Society of London: next month the British geologists will celebrate the event, and their pleasure will be enhanced by the sympathetic presence of a distinguished company of foreign geologists.

With a just feeling of satisfaction may we celebrate this event: for to the Geological Society of London is due the conversion of geology from a fanciful speculation to an ordered science. Yet so quietly has this society done its work that the debt due to it is inadequately realised. When we consider what the world owes to geology in respect of its economic guidance, the intellectual stimulus of its conceptions, the reverence it inspires for the venerable and majestic

universe, its liberating influence from dogma, we may rightly regard the work of the Geological Society as one of the most valuable British contributions to intellectual progress during the nineteenth century.

A hundred years ago the spirit of the eighteenth century still controlled much of the then orthodox geology. Jameson's "Elements of Geognosy," of which the preface is dated January 15th, 1808, taught, as the certain conclusions of geology, doctrines that had been reached by applying prejudiced speculation to imaginary facts. It was a manual of pure, *à priori*, Wernerian geology. The author claimed that to Werner "we owe almost everything that is truly valuable in this important branch of knowledge"; and that it was Werner "who had discovered the general structure of the crust of the globe and pointed out the true mode of examining and ascertaining those great relations which it is one of the principal objects of geognosy to investigate."

But Jameson's book was the death-song of Wernerian geology in British science. A new geology was developing, and the Geological Society of London ushered in its birth. No more should observations be made through the distorting medium of preconceived fancies! No more should geology be inspired by that heedless spirit which cares not to distinguish between fancy and fact! With youthful vigour the new geology would have nothing to do with the search for cosmogonies and such like fancy foods; and the Geological Society of London should be nourished on unadulterated facts.

The time was ripe for the change. No less a person than Goethe, once an enthusiastic votary of geology, was now, in his play of "Faust," holding up its teachers to ridicule. The theories "evolved from the inner consciousness" of Continental Neptunists and Plutonists were to Goethe excellent subjects for caricature. It was then the Englishman, Greenough, founded a society to turn geology from the pursuit of fleeting fancies and lead her to the study of sober but enduring facts. The members of this society were to abandon the quest of scientific chimæras; they were to leave to later generations the attempt to solve the universe as a whole.

The Geological Society has owed its influence to its bold, original purpose. It was not founded as a drifting social union of men with a common interest in a single science. Its object was to apply to geology one particular mode of research. It adopted as its motto this fine passage from Bacon:—

"If any man makes it his delight and care—not so much to cling to and use past discoveries, as to penetrate to what is beyond them—not to conquer Nature by talk, but by toil—in short, not to have elegant and plausible theories, but to gain sure and demonstrable knowledge: let such men (if it shall seem to them right), as true children of knowledge, unite themselves with us."

The methods of the society were as practical as its ideals. London, with characteristic unconventionality and originality, has used its scientific societies as its university for post-graduate teaching. Informally the Geological Society enrolled every British master of geology on its staff of unpaid professors, then set each of them to

teach the branch of geology which he knew best. And these professors were no carpet knights; they were knights errant who derived their knowledge, not from books alone, but from their wanderings over hills and dales, in mines and quarries, by ice-polished rocks and water-worn valleys. At its meetings the leaders of the society announced what they had discovered, gave sure and demonstrable proofs of their discoveries, and showed in what direction the geological forces should be directed for the conquest of Nature. The goodly fellowship of the Geological Society has always encamped on the ever-advancing frontier of geological knowledge, where the well-surveyed tracks pass out into the bright, alluring realms of the unknown.

The actual founders of the Geological Society were apparently men of less showy intellect than the great Werner, whose teaching had intoxicated many of the most gifted of his enthusiastic pupils. They were men, like Horner and Greenough, who had a practical insight that enabled them to give a permanent help to the progress of science. They had that supreme gift, the power to see things as they are. It would not be fair to claim for them that they were the originators of accurate methods in geology; such methods had been used before their day—by William Smith in England, by Lehman in Germany, and by Desmarest in France. But these men, acting singly, had not been able to save geology from the eighteenth-century spirit of adventurous speculation, nor had they lifted from geology the burden of those quaint theories that made this science the butt of Voltaire's luminous ridicule.

The great achievement of the Geological Society has been this: as a corporate body it has been able to spread its influence very widely; its clear-sighted pursuit of a practical ideal has been adopted in other countries; its resolute rejection of the temptation to wander in dream-land has affected geological students all over the world. In this way has been laid a broad foundation of positive knowledge upon which modern geology has been built.

The fine self-restraint which induced the founders of the Geological Society to restrict its work for awhile to observing the surface of the earth has had its reward. The methods this society was founded to employ have been so widely used that we now have geological maps of a wider area than was known to geographers of a century ago. The general distribution of all the rocks on the earth's surface has been discovered; most settled countries have been surveyed in some detail; the main outlines of the history of life on the earth have been written and carried back almost as far as palæontologists are likely to go. There are doubtless fossiliferous areas still undiscovered in the 'back blocks' of the world; but, though negative predictions are proverbially reckless, it seems probable that palæontology will not carry geological history materially farther back. Fossils have been discovered in the præ-Cambrian rocks; the best known is the fauna described by Walcot from Montana; but his Beltina, the oldest well-characterised fossil, is still of Palæozoic type. It may be that the poverty of carbonate of lime, which is so characteristic a feature of most Cambrian and præ-Cambrian sediments, indicates that the bulk

of the contemporary organisms had chitinous shells or were soft-bodied. Palæontology begins with the appearance of hard-bodied organisms; it can only reveal to us the dawn of skeletons, not the dawn of life. We are dependent for knowledge of the climate and geography of Eozoic time to the evidence of the sediments, of which there are great thicknesses beneath the fossiliferous rocks in most parts of the world.[1]

II. *The Geology of the Inner Earth.*—Now that this geological survey of the earth is in rapid progress; while the history of life has been written at least in outline; the chief fossils, minerals, and rocks have been described and generously endowed with names; and the manifold activity of water and air in moulding the surface is duly appreciated, it is not surprising to find that the centre of geological interest is shifting to the deeper regions of the earth's crust and to the problems of applied geology. The secrets of these deeper regions are both of scientific and economic interest. They are of scientific importance, for it is now generally recognised that the main plan of the earth's geography and the essential characters of the successive geological systems are the result of internal movements. The relative importance of those restless external agents that we can watch, denuding here and depositing there, has been exaggerated; probably they do little more than soften the outlines due to the silent heavings produced by the colossal energies of the inner earth.

The study of the deeper layers of the crust is of economic interest, for, with keener competition between increasing populations and with the exhaustion of the most easily used resources of field and mine, there is growing need for the better utilisation of soils and waters, and for the pursuit of deeper deposits of ore.

If a shaft be sunk at any point on the earth's surface a formation of Archæan schists and gneisses would probably always be reached; and, working backward, geological methods always fail at last—in primæval, Archæan darkness. The Archæan rocks still hide from us the earlier period of the earth's history, including that of all rocks which now lie beneath them. But already there are indications that the mystery of the 'beyond' is not so impenetrable as it seemed.

1. *The Nebular and Meteoritic Hypotheses.*—The eighteenth century explained the history of the earth by the nebular hypothesis of Laplace. Geologists respectfully adopted this idea from the astronomers: they accepted it as one of those essential facts of the universe with which geological philosophy must harmonise. The resulting theory represented the earth as originally a glowing cloud of incandescent gas, which slowly cooled, until an irregular crust of rock formed around a gaseous or molten core; as the surface grew cooler, the depressions in the crust were filled with water from the condensing vapour, forming oceans which became habitable as the temperature further fell. The whole earth was thought to have had

[1] Such are the Algonkian sediments, represented by the Huronian and Algonkian of America, the Algonkians of Scandinavia, the Karelian of Finland, the Brioverian of North-West France, the Heathcotian of Australia, the Transvaal and Swaziland systems of South Africa, the Dharwar and Bijawar systems of India, the Itacolumite series of Brazil, etc.

a long period with a universal tropical climate, under which coral reefs grew where flow our polar seas, and palms flourished on what are now the Arctic shores. Still further cooling had established our climatic zones; and it was predicted that in time the polar cold would creep outward, driving all living beings toward the equator, until at length the whole earth, like the moon, would become lifeless through cold, as it had once been uninhabitable through heat. This theory has permanently impressed itself on geological terminology; and its corollaries, secular refrigeration and the contortion of the shrinking crust, once dominated discussions concerning climatic history and the formation of mountain chains. This nebular hypothesis, however, we are now told, is mathematically improbable, or even impossible; and it is only consistent with the facts of geology on the assumption that, in proportion to the age of the world, the whole of geological time is so insignificant that the secular refrigeration during it is quite inappreciable; hence geology can no more confirm or correct the theory than a stockbreeder could refute evolution by failing to breed kangaroos into cows in a single lifetime.

The theory of the gaseous nebula has been probably of more hindrance than help to geologists; its successors, the meteoritic hypothesis of Lockyer and the planetismal theory of Chamberlin, are of far more practical use to us, and they give a history of the world consistent with the actual records of geology. According to Sir Norman Lockyer's meteoritic hypothesis, nebulæ comets and many so-called stars consist of swarms of meteorites which, though normally cold and dark, are heated by repeated collisions, and so become luminous. They may even be volatilised into glowing meteoric vapour; but in time this heat is dissipated, and the force of gravity condenses a meteoritic swarm into a single globe. Some of the swarms are, says Lockyer, "truly members of the solar system," and some of them travel around the sun in nearly circular orbits, like planets. They may be regarded as infinitesimal planets, and so Chamberlin calls them planetismals.

The planetismal theory is a development of the meteoritic theory, and presents it in an especially attractive guise. It regards meteorites as very sparsely distributed through space, and gravity as powerless to collect them into dense groups. So it assigns the parentage of the solar system to a spiral nebula composed of planetismals, and the planets as formed from knots in the nebula, where many planetismals had been concentrated near the intersections of their orbits. These groups of meteorites, already as solid as a swarm of bees, were then packed closer by the influence of gravity, and the contracting mass was heated by the pressure, even above the normal melting-point of the material, which was kept rigid by the weight of the overlying layers.

This theory has the recommendation of being consistent with the history of the earth as interpreted by geology. For whereas the nebular hypothesis represents the earth as having been originally intensely hot, and having persistently cooled, yet geological records show that an extensive low-level glaciation occurred in Cambrian times in low latitudes in South Australia[1]; indeed, it seems probable

[1] As shown by the work of Professor Howchin, of Adelaide.

that, in spite of many great local variations, the average climate of the whole world has remained fairly constant throughout geological time. Whereas it has often been represented, in accordance with the nebular theory, that volcanic action has steadily waned, owing to the lowering of the earth's internal fires and the constant thickening of its crust, yet epochs of intense volcanic action have recurred throughout the world's history, separated by periods of comparative quiescence. Whereas it has been assumed, as a corollary to the nebular theory, that the force which uplifted mountain chains was the crumpling of the crust owing to the contraction of the internal mass, yet observation reveals that the crust has been corrugated, and fold mountains formed by contraction to an extent far greater than secular cooling can explain.

2. *The Materials of the Inner Earth.*—This planetismal hypothesis is not only consistent with geological records, but also with the known facts as to the internal composition of the earth and the structure of extra-terrestrial bodies as revealed by meteorites. Meteorites are of two main kinds—the meteoric irons, which consist of nickel iron, and stony meteorites, which are composed of basic minerals. Some of the stony meteorites have been shattered into fault breccias, showing that they are fragments of larger bodies which were subject to internal movements, like those that have formed crush conglomerates in the crust of the earth. Those stony meteorites, therefore, both in composition and structure resemble the rocks in the comparatively shallow fracture zone of the earth's crust. The nickel-iron meteorites, on the other hand, represent the barysphere beneath the crust.

The earth appears to consist of material similar to that of the two types of meteorites; but whether the proportions of the two materials in the earth represent their proportions in other bodies and in meteoric swarms is problematical. There appear to be no satisfactory data for an estimate of the relative abundance in space of the iron and stony meteoric material. Stony meteorites have been seen to fall far more frequently than iron meteorites; but the largest known meteorites are of the nickel-iron group, although this material, in moist climates, very soon decays. The most reliable indication as to the relative amounts of the stony and nickel-iron meteorites is given by a comparison of the weight of the two types of material in meteorites of which the fall was seen. According to Mr. Fletcher's list of the meteorites in the British Museum up to 1904, the collection included 319 specimens of which the fall is recorded: of them 305 specimens were stony meteorites of an average weight of 2·63 lbs., 9 were iron meteorites of an average weight of 2·31 lbs., and 5 were siderolites (or meteorites containing a large proportion of both silicates and nickel-iron) of an average weight of 54 lbs.[1] Therefore, according to this test, the stony materials would appear to be the more abundant. But if all known meteorites are considered, the iron group far outweighs the other; for the iron meteorites in the British Museum

[1] The weights are given in pounds avoirdupois. For the calculation I am indebted to Mr. W. R. Wiseman, of the Geological Department of Glasgow University.

collection weighed 11,873 lbs., as against a total weight of only 865 lbs. of stony meteorites. The available evidence suggests that the stony meteorites fall the more frequently on the earth, but the meteoric irons come in such large masses that they outbalance the showers of the smaller stones.

We might have expected help from another source in examining what lies below the Archæan rocks. Cannot the relative proportions of the stony and metallic constituents in the earth help us? Unfortunately, this proportion is as uncertain as that of stony and iron meteoritic material. The best-established fact about the interior of the earth is that its materials are much heavier than those of its crust. The specific gravity of the earth as a whole is about 5·67; the specific gravity of the materials of the crust may be taken as about 2·5, while that of the heavier basic rocks is only about 3·0. Hence the earth as a whole weighs about twice as much as it would do if it were built of materials having the same density as those which form the crust.

Two explanations of the greater internal weight of the earth have been given. According to one, the earth is composed throughout of the same material, and the internal mass is only heavier because it is compressed by the weight of the overlying crust. Laplace estimated that the material would gradually increase in density from the surface to the centre, where its specific gravity would be 10·74, and the calculations of Schlichter show that condensation due to compression may be adequate to account for the greater internal weight.

According to the alternative or segregation theory, the difference in density is explained as due to a difference in composition; the interior of the earth is thought to be heavier owing to the concentration of metals within it. The probability of this metallic interior has been advanced from several lines of evidence; and the assumed metallic mass has received from Posepny the name of the 'barysphere,' or heavy sphere. According to this view the earth is essentially a huge ball of iron, which, like modern projectiles, is hardened with nickel; and it is covered by a stony crust, the materials of which were primarily separated from the metallic mass, like the slag formed on a ball of solidifying iron in a puddling furnace.

It has been objected that the weight of the earth is not great enough for much of it to be composed of metallic iron or of meteoritic material. The specific gravity of iron under the pressure at the earth's surface is about 7·7, and it would be even greater when compressed in the interior. But the barysphere is doubtless impregnated with much stony material that would lessen its weight. An estimate by Farrington (1897) of the average specific gravity of the meteorites of which the fall had been recorded is only 3·69. According to the Rev. E. Hill (1885) the mean specific gravity of all the meteorites in the British Museum was 4·5; and, though Mr. Hill duly considered the effect of compression, he concluded that "the density of the earth is perfectly consistent with its being an aggregation of meteoric materials." Moreover, within the metallic barysphere there may be a core of lighter material; for earthquake

waves travel more slowly in the central core of the earth than in the intermediate zone, or are even suppressed altogether there; hence the centre of the earth may be occupied by matter less compact than that of the shell around it; and, according to Oldham's calculations, the light central core occupies two-fifths of the diameter of the earth.

The evidence of density alone, therefore, gives no convincing evidence of the nature of the earth's interior; and geologists have been left with no conclusive reason for choosing between the condensation and segregation theories. Radio-activity has, however, unexpectedly come to our aid, and has disclosed a further striking resemblance between the internal mass of the earth and the iron meteorites. It has supplied direct evidence about the constituents of the earth at depths which have hitherto been far beyond the range of observation. Mr. Strutt has shown that radium is probably limited within the earth to the depth of 45 miles, that the deeper-lying material is free from radium, and that this substance is not found in iron meteorites.

The agreement in radio-active properties between the iron meteorites and the interior of the earth is an additional and weighty argument in favour of the view that the earth is largely composed of nickel iron.

3. *Physical Conditions and Temperatures.*—The physical condition in which the material exists is now of secondary interest. The old controversy as to whether the earth has a molten interior inclosed within a solid shell has lost its importance, because it has become a mere matter of definition of terms. The facts which led geologists to believe that the interior of the earth is fluid are consistent with those which prove that the earth is more rigid than a globe of steel. For under the immense pressure within the earth the materials can transmit vibrations and resist compression like a solid; but they can change their shape as easily as a fluid. They are fluid just as lead is when it is forced to flow from a hydraulic press. Not only are geologists now justified in their belief that the deeper layers of the earth's crust are in a state of fluxion, but, according to Arrhenius (1900), the earth is solid only to the depth of 25 miles, below which is a liquid zone extending to the depth of 190 miles; and below that level, he tells us, "the temperature must, without doubt, exceed the critical temperature of all known substances, and at this depth the liquid magma passes gradually to a gaseous magma." This distinguished physicist gives a description of the earth's interior which reminds us of the views of the early geologists. Arrhenius's theory rests, however, on the existence within the earth of exalted temperatures; and this assumption a geologist may now hesitate to accept with less risk of getting into disgrace than he would have run a few years ago. It is improbable that the rapid increase of heat with depth which is observed near the surface should continue below the lithosphere; for, if the earth consists in the main of iron, even although it be arranged as a mesh containing silicates in the interspaces, the heat conductivity might be sufficient to keep the whole metallic sphere at a nearly equal temperature. Here, again, Mr. Strutt's work on radio-activity is in full agreement with the requirements of geologists, for he estimates that below a crust 45 miles thick the earth has a uniform

temperature of only 1,500° C. Whether the further conclusion that this heat is due to the action of the radium in the crust be established or not, it is gratifying to hear a physicist arguing in favour of a moderate and uniform internal temperature.

All that the actual observations prove and that geological theories require is that the material within the earth be intensely hot, and that it lie under such overwhelming pressure that it would as readily change its form and as quickly fill up an accessible cavity as any liquid would do. Whether such a condition is to be described as solid, liquid, or gaseous is of little concern to geologists.

III. *The Deep-seated Control over the Earth's Surface.*—The modern view of the structure of the earth adds greatly to the interest of its study, for it recognises the world as an individual entity of which both the geological structure and the history have to be considered as a whole. Once the earth was regarded as a mere lifeless, inert mass which has been spun by the force of gravity, that hurls it on its course into the shape of a simple oblate spheroid. Corresponding with this astronomical teaching as to the shape of the world was the geological doctrine that all its topography is the work of local geographical agents, whose control over the surface of the earth is as absolute as that of the sculptor's chisel over a block of marble.

Both these conceptions are now only of historic interest. The irregular individual shape of the earth is expressed by its description as a geoid. The processes which have produced its varying shape have also controlled its geological history and evolution, for they cause disturbances of the crust, which affect the whole earth simultaneously; and so the geographical agents are given similar work and powers at the same time in different places.

Hence there is a remarkable worldwide uniformity in the general characters of the sedimentary deposits of each of the geological systems. The last præ-Cambrian system includes thick masses of felspathic sandstones alike in the Torridonian of Scotland, the sparagmite of Scandinavia, the Keweenawan Sandstones of the United States, and perhaps also the quartzites of the Rand. The Cambrian has its greywackes and coarse slates and its numerous phosphatic limestones; the Ordovician its prevalent shales and slates; the Silurian its episodal limestones and shales. The Devonian has its wide areas of Old Red Sandstones as a continental type, while its marine representatives show the prevalence of coarse grits and sandstones in the lower series, of limestones and slates in the middle series, and the recurrence of sandstones in the upper series; and this sequence occurs alike in North-Western Europe, in America, and Australia. The Carboniferous contains the first regional beds of thick limestone and the first important Coal-measures. The Trias is as characterised by rocks indicating arid continental conditions in America and Australia and South Africa, as Professor Watts has shown them prevailed in the neighbourhood of Leicester. In the Mesozoic era we owe to Suess the demonstration of the worldwide influence of those marine encroachments or 'transgressions' whereby the great continents of the Trias were gradually submerged by the rising sea.

Speaking generally, there is a remarkable lithological resemblance

between contemporary formations in all parts of the world. This fact had been often remarked, but was usually dismissed as due to a number of local isolated coincidences of no special significance. But the coincidences are too numerous and too striking to be thus lightly dismissed. They are among the indications that the main earth-changes have been due to world-wide causes, which led to the predominance of the same types of sedimentary rocks during the same period in many regions of the world.

The conditions that govern the geological evolution and general geography of the earth are probably due to the interaction between the earth's crust and the contracting interior; they may take place as slow changes in the form of the earth, causing the slow rising or lowering of the sea surface, or the slow uplift or depression of regions of the earth's crust; or they may give rise to periods of violent volcanic action in many parts of the earth, between which may be long periods of quiescence. The geographical effects of changes in the earth's quivering mass affect distant regions at the same time. Therefore the landmarks of physical geology will probably be found to give more precise evidence as to geological synchronism than those of palæontology, on which we have hitherto had to rely.

(*To be concluded in our next Number.*)

II.—British Association for the Advancement of Science. List of Titles of Papers read in Section C, Geology, August 1st to 7th, 1907.

Presidential Address by Professor J. W. Gregory, F.R.S. (p. 409.)

C. Fox-Strangways.—Geology of Country round Leicester. (p. 420.)

Professor W. W. Watts, F.R.S.—The Geology of Charnwood Forest.

Dr. F. W. Bennett.—The Felsitic Agglomerate of Charnwood Forest.

Dr. B. Stracey.—The North-West District of Charnwood Forest. (p. 420.)

A. R. Horwood.—The Palæontology of the North Derbyshire Coalfield. (p. 421.)

H. T. Ferrar.—Some Desert Features.

Trias Report—Investigation of the Fauna and Flora of the Trias of the British Isles.

(*a*) *Dr. Smith Woodward.*—On *Labyrinthodon leptognathus*, Owen.

(*b*) *H. C. Beasley.*—Footprints from the Trias.

(*c*) *J. Lomas.*—Footprint Slab in Museum of University of Liverpool.

(*d*) *A. R. Horwood.*—The Flora and Fauna of the Trias.

(*e*) *L. J. Wills.*—Fossils of the Lower Keuper of Bromsgrove.

Professor H. G. Seeley, F.R.S.—On the Structure of the Mandible of a South African Labyrinthodont.

T. O. Bosworth.—The Origin of the Upper Keuper.

W. Keay & M. Gimson.—The Relation of the Keuper Marl to the Pre-Cambrian Rocks at Bardon Hill.

H. Bolton & C. J. Waterfall.—On the Occurrence of Boulders of *Strontia* in the Upper Triassic Marls of Abbott Leigh, near Bristol.

Dr. Callis.—On a peculiarity in the Mineralogical Constitution of the Keuper Marl.

Discussion on "Iron Ore Supplies," to be opened by Bennett Brough and Professor Sjögren.

Professor J. Joly.—The Distribution of Radium in the Rocks of the Simplon Tunnel.

W. G. Fearnsides.—On Pisolitic Iron-ores from North Wales. (p. 422.)

F. Raw.—The Trilobite Fauna of the Shineton Shales.

F. Raw.—Development of *Olenus Salteri*.

Dr. A. Vaughan.—Report on Carboniferous Faunas.

W. G. Fearnsides.—Report on Place-Names.

Professor S. H. Reynolds.—Report on Pre-Devonian Rocks of the Mendips.

Professor J. Milne, F.R.S.—Destructive Earthquakes.

Professor Frech.—Mountain Building and Seismology.

J. W. Stather.—Report on Kirmington Deposits.

J. W. Stather & T. Sheppard.—Gravels of Holderness.

J. Lomas.—On a Marine Peat at Liverpool.

A. R. Horwood.—A Section of Middle Lias at Bellesdon.

Rev. S. S. Dornan.—Ancient Volcanoes of Basutoland.

E. Greenly.—Report on Anglesey Rocks.

Dr. Wheelton Hind.—Report on Carboniferous Zones.

Report on Erratic Blocks.

Titles of Papers read in other Sections bearing upon Geology:—

Section A.—General Physics.

A. O. Rankine.—On a theoretical Method of attempting to detect relative Motion between the Ether and the Earth.

Report of the Committee on Seismological Observations.

Professor E. Rutherford, F.R.S.—On the Production and Origin of Radium.

Professor E. Rutherford, F.R.S., & Dr. J. E. Petavel, F.R.S.—The Effect of High Temperature on the Activity of the Products of Radium.

T. J. J. See.—Results of Recent Researches on the Physics of the Earth.

Section B.—Chemistry.

Professor Phillips Bedson.—Explosions in Coal-mines: Experiments illustrative of the Inflammability of Mixtures of Coal Dust and Air.

Section D.—Zoology.

Report of the Committee on the *Index Animalium*.

Section E.—Geography.

Professor J. W. Spencer.—The Recession of Niagara.

H. T. Ferrar.—Physical Geography of the Etbai Desert of Egypt.

Dr. Vaughan Cornish.—The Jamaica Earthquake.

SECTION H.—ANTHROPOLOGY.

Report of the Committee to conduct Explorations with the object of ascertaining the Age of Stone Circles.

Report of the Committee to Investigate the Lake Village of Glastonbury.

SECTION K.—BOTANY.

Professor F. W. Oliver, F.R.S.—On the Structure and Affinities of *Physostoma elegans* (Williamson), a Pteridospermous seed from the Coal-measures.

D. M. S. Watson.—The Cone of *Bothrodendron mundum.*

PAPERS READ IN SECTION C (GEOLOGY), BRITISH ASSOCIATION, LEICESTER, AUGUST, 1907.

III.—NOTES ON THE GEOLOGY OF LEICESTERSHIRE. By C. Fox-Strangways, F.G.S.

THE chief features of the district were briefly described, with a general account of the formations that are exposed throughout the county. These are comprised in the following main divisions in descending order: Recent and Pleistocene, Jurassic, Triassic, Permian, Carboniferous, and Pre-Cambrian. The first of these includes the river deposits and glacial beds. The Jurassic rocks comprise only the two lower subdivisions of the Lincolnshire Limestone and the Northampton Sand, together with the Lias. The Trias occurs in the usual two divisions of Keuper and Bunter. The Permian consists of breccia and marls, the age of which is to some extent doubtful. The Carboniferous is well exemplified in the three subdivisions of Coal-measures, Millstone Grit, and Limestone; but the lower beds are not of the importance they attain elsewhere. The Pre-Cambrian rocks are divisible into three main groups, as shown by Professor W. W. Watts—the Brand Series, the Maplewell Series, and the Blackbrook Series. Special attention was directed to the more important exposures of these rocks, and to the principal points in the local geology that are obscure and require further elucidation.

IV.—THE NORTH-WEST DISTRICT OF CHARNWOOD FOREST. By Bernard Stracey, M.B., F.G.S.

AS the north-west of Charnwood Forest is approached the rocks become more altered, the faulting is greater, and igneous rocks are met with. The vent which ejected the rocks of the forest seems to lie in this direction.

Bardon Hill.—The centre and part of the north flank are composed of rock resembling an igneous rock; evidence is given to show that this rock differs from the agglomerates found in the north-west area, with which it has hitherto been correlated. Certain rocks between the Bardon rock and the Peldar porphyroid seem to bear some relation to the felsitic agglomerate.

Birchill Plantation.—Recent research in this exposure has shown the identity of the rock with that found at Bardon Hill. On the north side rocks belonging to the Felsitic Agglomerate Series have also been found.

Peldar Tor.—The porphyroid exposed in the large quarries contains inclusions of other rocks, which have been generally considered as segregation masses. An undoubted dyke in the middle of Peldar Tor has been exposed.

Ratchet Hill.—An exposure in this hill shows the presence of rocks on the felsitic agglomerate horizon. At the north-west end a porphyroid occurs which seems to be identical with the porphyroid at Cadman Wood.

Swannymote and Trilobate.—Rock belonging to the Felsitic Agglomerate Series runs between these two places; it has been much altered, and has not hitherto been recognised as belonging to the felsitic agglomerate.

V.—A Contribution to the Palæontology of the North Derbyshire and Notts Coalfield, or the Southern Part of the North Midland Coalfield. By A. R. Horwood, Sub-Curator, Leicester Corporation Museum.

A SUMMARY was given of the extent and position of the North Midland Coalfield. Allusion was then made to the previous work connected with the palæontology of the district. This was very limited, and the correlation of the Top Hard Coal with the Main Coal of Leicestershire, and of the Black Shale with the Arley Mine of Lancashire, had not been founded on fossil evidence.

Recently the resurvey of the district by the Geological Survey and some important borings had added much to our knowledge of the fossil flora and fauna met with.

As a result of these investigations, and by the aid of a summary of all the previously recorded organic remains from this area, the author was able to arrive at the following conclusions:—

1. That the flora of the Top Hard Coal, as afforded by specimens from Pleasley, indicates that it is of the same age as that of the Main Coal of Leicestershire and South Derbyshire (in both the Western or Moira and Eastern or Cole Orton Districts), i.e. of Middle Coal-measure age, occupying a position rather more than midway in that division of the Coal-measures.

2. The fauna of the horizon at Mansfield, Notts, 630 feet above the Top Hard Coal, indicates, as pointed out by Mr. Walcot Gibson, a horizon equivalent to the Gin Mine or Twist Coal of the North Staffordshire Coalfield, i.e. near the top of the Middle Coal-measures and commencement of the Transition series, or Black Band group, which would occupy a position slightly higher. Eastward and above this horizon the whole of the Upper Coal-measures are represented, though feebly developed.

3. The Coal-measures of North Derbyshire are, as a whole, entirely confined to the limits of the Grey or chief coal-bearing series (Lower

and Middle Coal-measures), like the Leicestershire and South Derbyshire Coalfield, of which it is a continuation; and none of the Red series (or Transition series and Upper Coal-measures) of the North Staffordshire type are met with in this area west of a line somewhat east of the Nottinghamshire and Derbyshire County boundary between Bolsover and Stanton, though this line probably curves westward in the north, just south of Rotherham, and eastwards, south and south-east of Nottingham.

A summary of the fossil flora and fauna of North Derbyshire and Nottinghamshire, as at present known, was given, with the horizon and locality of the specimens cited. This, though preliminary, was in extension of the work already accomplished in the Leicestershire and South Derbyshire Coalfield, shortly to be published, and in other fields, and supplementary to the work of Ward, Hind, and Stobbs in the North Staffordshire Coalfield on the mollusca and fish fauna of that area, and of Kidston on the fossil floras of Yorkshire and North and South Staffordshire.

VI.—On the Pisolitic Iron-ores of Wales. By W. G. Fearnsides, M.A., F.G.S.

THE first part of the paper discusses the occurrence of the well-known iron-ores of Caernarvon and Merioneth, and shows that though they have been taken by various writers as marking a well-constituted subdivision of the Tremadoc slates they are really of the nature of fissure phenomena, and may occur at almost any horizon.

The various worked exposures seem always to agree in the following particulars:—

(1) They are associated with the occurrence of large hypabyssal or minor plutonic intrusions of sill-like habit, and occur among stratified rocks along the limit of the sill's metamorphic area.

(2) They occur in more or less lenticular masses, of no considerable lateral extent, often heaped together and separated by crushed shale partings in a way which may suggest bedding, but often thinning out yet maintaining a linear arrangement across considerable tracts of country.

(3) Considerable lenticles of ore are always associated with dark-blue or black shales or slates, which nearer to the igneous intrusion have become bleached and spotted through the influence of that intrusion. On the side of the ore body nearest the intrusion the country rock is usually little disturbed, and lies evenly, but on the side remote from the intrusion the country rock is crossed and recrossed by planes of slickenslide, and is often intensely nodular.

The more important stratigraphical horizons which have developed pisolitic ore bodies in the North Welsh district are:—

(1) Lower Lingula flags. Bettws Garmon. Black shales which underlie the grey flaggy sandstones with *Lingulella* beds.

(2) Upper Lingula flags. North flank of Aron Mawddy. Adjoining shales contain *Peltura scarabaeoides*.

(3) Upper Arenig Shales. Moelwyn Bach; Milltirgerig, Arenig; below Llyn y gader, Cader Iris. Country rock contains abundant *Didymograptus bifidus*.

(4) Llandeilo Shales (Glenkiln facies). - Tiddyn Diewm, Tremadoc. Country rock contains graptolites of the *Didymograptus Murchisoni* and *Cœnograptus gracilis* zones.

The workings of Pistyll near the Rivals seem to belong to a horizon higher than any of these, and may be among the Hartfell (Bala) shales.

The second portion of the paper deals with the probable petrological and chemical history of the iron-ores.

Evidence is brought forward to show that the ore bodies have been only profitable near the present surface, and when smelted with wood charcoal. They are always very rich in pyrites or marcassite, which in certain specimens from the deep termination of an adit makes up about 60 or 70 per cent. of the rock. The ores are always impure, and contain much crushed, streaky or fibrous shale between the pisoles. Where freshest the pisoles of sulphides show only radial arrangement of the constituent fibres, but there may also be concentric structures which are masked by the opacity of the mineral. The radial fibres of sulphidic minerals usually grow out from or around quartz grains or other clastic fragments of country rock or of earlier formed pisolite grains. During oxidation the sulphidic material is attacked in stages from the outside and passes by obscure processes, first to a colourless and soluble green pleochroic mineral, and afterwards to fibrous limonite and compact magnetite, and it is the differential development of the various stages which gives the resultant pisoles of the profitable ore their well-marked concentric structure.

That all the pisolitic grains contained in the iron-ores of North Wales have been formed as radial growths of iron sulphides is not yet clear, but the method of their geological occurrence will well accord with the hypothesis that they may be the concentration products of the non-carbonaceous colouring matters driven off by the heat of the intrusion from the black shales considered above.

An occurrence of perfectly fresh masses of radial pyrites at the limit of a 12–20 feet metamorphic aureole in the Llandeilo shale of Harper Quarry, Builth, shows that such concentration can occur on a small scale, while the finding of considerable lenticles of iron-ore which are wholly pyrites, and have been concentrated during the turning of coal into anthracite in the Emlyn Mine, Llanleby, near Llandeilo, would seem to show that recrystallized pyrites does tend to take on a pisolitic habit.

REVIEWS.

Australian Geology.

Stanford's Compendium of Geography, etc. New issue, 1907. Australasia. Vol. I: Australia and New Zealand. By J. W. Gregory, D.Sc., F.R.S., Professor of Geology in the University of Glasgow. (London: Edward Stanford.)

THE whole of this volume abounds with geographical and geological references, as might be expected from the author, and is also exceedingly well illustrated with maps, etc. Chapter iv, "The

Geographical Structure and Resources of Australia," pp. 84–115, contains the geological map facing p. 104, and there is also a physical map facing p. 84, with a small map on p. 93 showing the main geographical divisions. Gregory considers that, with the exception of the east coast of Australia, the coasts as a rule have no intimate connection with the geological structure of the adjacent lands. The course of these coasts has been determined by great subsidences, which have formed the ocean basins round Australia, instead of by movements parallel to the shore. The great arm of the sea on the south coast, known as Spencer Gulf, has been formed by subsidence along two lines of fault, being in fact a rift-valley. This depression seems to be continued in the great central plain system terminating in the Gulf of Carpentaria on the north.

There are, in fact, three very unequal and dissimilar areas constituting the Australian continent. Commencing from the eastward, the first and by far the most interesting division is that of the East Australian highlands and its dependencies; this mountain-system roughly conforms to the east coast from Torres Strait to Bass Strait, curving round to face the latter, where it constitutes the highlands of Victoria. It is in the angle thus formed, in the extreme south-east of the continent, where the mountain-system attains its maximum development. On the seaward side of the East Australian highlands are areas of coastal plain, which in New South Wales are of considerable width, and usually contain the most important centres of population. On the landward side of the mountain-system, both in Queensland and New South Wales, the country gradually slopes towards the central depressed area, shooting off its surplus water either by the Murray system into the sea, or by interior drainage towards the Lake Eyre basin. The geological structure of these eastern highlands is complex, and bears but little resemblance to a typical mountain chain. There is a considerable mass of crystalline rock, described as Archæan and plutonic, in the northern part of the Queensland section, which is unassociated with any development of the older Palæozoics, but lies the sea on one side and rocks of Cretaceous age on the other. In the central portion of the highlands, between lat. 25° and 30° S., Archæan rocks are indicated which in some cases are flanked by the older Palæozoics, whilst in the south-east corner (New South Wales and Victoria) there are several masses of Archæan rock associated with a much larger development of the older Palæozoics. The most important display of Carboniferous rocks is to be found in the region lying between 20° and 35° S. lat. This subject had best be considered under the separate Colonies. Patches of Triassic and Jurassic rock occur here and there, and there is a large development of Tertiary volcanics throughout this division, which appears to attain their widest extension in the Great Valley of Victoria. The entire mountain-system consists in a geographical sense of a series of plateaux, and Professor Gregory assures us that the highest summit in Australia, Mount Kosciusko (7,336 feet), is only a blunt hummock on the surface of a high plateau. These plateaux have been greatly dissected, so that the gorges are numerous and deep, and he further points out that the best-known mountains visible from the coast are

only the scarps of the inland plateau. This rule applies also to the third grand division, viz. Westralia.

The second grand division also runs south and north from the southern sea to the Gulf of Carpentaria, and is described as the region of the Great Plains, formed, Professor Gregory thinks, by subsidence. A large portion of this is less than 500 feet above sea-level; the shores of Lake Eyre are said to be 39 feet below that level. It is, in fact, an extensive basin whose further submergence would tend to convert the continent of Australia into two separate islands. The greater part of this depressed area is occupied by rocks of Cretaceous age as determined by their fossils.

The third grand division is larger than the other two combined, and consists of an endless series of upland plateaux of moderate elevation up to about 2,000 feet, much of which is practically a desert. This immense mass consists to a great extent of Archæan rocks associated in the north-east with a wide stretch of older Palæozoics, though parts of the interior may be still unexplored. It appears to have been unsubmerged, like peninsular India, for a long period; and has a fringe of newer rocks on its western margin, in which the early settlements of Western Australia are situated. The mineral resources of this and the two other grand divisions of the Australian continent may be gathered from Professor Gregory's separate notices of the individual Colonies.

New South Wales.—As previously noted in considering the character of the East Australian highlands, the south-eastern corner is composed of Archæan and Lower Palæozoic rocks, mostly striking north and south. These older rocks gradually decrease in height as they are followed northwards, until they disappear below the Upper Palæozoic rocks which contain the great coalfields. To the north of this area the older rocks reappear and are continued to the Queensland frontier. The mountains result in the main from the dissection of plateaux by river action. These are in a very youthful stage of dissection, and their marvellous gorges and cliffs—expressions of youth—provoke the wonder of the beholder by reason of their diverse forms. The lavas of Tertiary age, which occur in some places, also lend themselves to this kind of scenery, and there are peaks west of the Blue Mountains which consist of trachyte and andesite. On the east side of the mountain system the coastal plains have an average width of 40 miles, though in the valley of the Hunter River the width reaches 150 miles. The western plains, on the other side of the mountain-system, include some of the largest true plains in the world. They are mostly dry, but sometimes in places so flooded that steamers have been known to discharge their cargoes 25 miles away from the main channels.

As regards the geological structure of New South Wales, Professor Gregory observes that the block of older rocks was divided into two parts in Middle Palæozoic times by the great valley now occupied by the basin of the Hunter. This basin was filled with Carboniferous sediments, which were deposited upon the upturned edges of pre-existing strata. In contrast to the north and south strike of the older rocks, these Carboniferous beds strike from east to west. Referring

to the pre-Carboniferous beds, he observes that Upper Ordovician, known by its graptolite fauna, is widely distributed throughout New South Wales, the limestones being full of corals, the shales yielding many trilobites and the sandstones many brachiopods.

The beds of Carboniferous age are interesting from their economical importance, for at present this colony retains its lead over Queensland in coal production. There is a section (by J. E. Carne) on page 282, across part of the Blue Mountains, where, on upturned slates and quartzites, said to be Devonian, beds of Permo-Carboniferous age (Upper Marine and Upper Coal-measures) are succeeded by beds of Triassic age. This section is also remarkable as showing the weird sculpture of the district in question. A boring in Sydney harbour shows coal-bearing beds at a depth of 3,000 feet; hence the available coal-area is not to be judged merely by the extent of the Carboniferous outcrop. On p. 315 the full development of the Permo-Carboniferous rocks (classified by Professor David) is given as follows:—

	Thickness. Feet.
1. Upper or Newcastle Coal-measures, containing an aggregate of about 100 feet of coal	1,150
2. Dempsey Series: fresh-water beds, containing no productive coal: thins out in some directions	2,000
3. Middle (East Maitland) Coal-measures, with about 40 feet of coal	570
4. Upper Marine Series: characterized by *Productus brachythaerus*	5,000
5. Lower or Greta Coal-measures, with about 20 feet of coal ...	130
6. Lower Marine Series, with *Eurydesma cordata*	4,800
	13,650

The Mesozoic deposits of New South Wales include representatives of the Triassic, Jurassic, and Cretaceous systems. The fossil plants of the Hawkesbury Series (Triassic) are different to the *Glossopteris* fauna of the Permo-Carboniferous. There is no good development of Jurassics. The Cretaceous beds are divided into two series—the Rolling Downs formation, which underlies the Darling Plains and is regarded as Lower Cretaceous; the 'Desert Sandstone' contains the bones of *Cladiosaurus*, sometimes converted into precious opal, and is regarded as Upper Cretaceous. Tertiary volcanic rocks have a wide distribution.

Queensland.—The metamorphic rocks and the schists occur in three main areas, and associated with these foliated rocks are a series of ancient plutonic masses and of other igneous rocks. All these are either Archæan or Lower Palæozoic. The Carboniferous system here is divided into five series, of which three are developed in the Bowen River Coalfield, ranging from 20½ to 26° S. lat. The Upper Bowen Beds are full of *Glossopteris* and contain many coal-seams. The coal-producing series of rocks is continued into the Mesozoic period (Trias-Jura), where *Taeniopteris* takes the place of *Glossopteris*.

Of the Cretaceous system, the lower series consists of marine clays, which constitute the Rolling Downs formation, forming the surface, or underlying nearly three-fourths of Queensland. It is of economic importance as causing the impermeable cap which keeps down the

water of the Flowing Wells. The Upper Cretaceous series consists of sandstones, quartzites, etc. (containing *Glossopteris?*), which are continuous with beds of Desert Sandstone. This peculiar formation, which probably has only one-twentieth of its former extent, is partly marine, partly terrestrial, and has undergone much silicification. The Cainozoic system is mainly represented by volcanic rocks, which began to flow early in Tertiary times. The most interesting of the higher deposits of this age are some breccias, rich in the bones of extinct marsupials and birds, associated with fresh-water mollusca, such as *Melania*, *Limnæa*, *Physa*, etc.; also teeth of *Ceratodus*.

Victoria.—Although this is the smallest of the states or colonies of the mainland of Australia, its geology is more complex than that of any other. The dominant fact in its geological structure is that it consists of a base of Lower Palæozoic and Archæan rocks which have been thrown into a series of folds along two lines nearly at right angles to each other. The oldest rocks are Archæan, and the Lower Palæozoics are well represented, especially in the case of Ordovician sediments, which possess a peculiar interest from the circumstance that auriferous reefs, such as those at Bendigo and Ballarat, are connected with this formation. Bendigo is situated on a northern spur of the Victorian highlands, and Ballarat on a southern spur of this mountain complex.

Gold-mining in Victoria is by far too large a subject for the present review, seeing that it has yielded something like £250,000,000 in the course of its history. There is, however, an interesting notice (Science Progress, July, 1906) by Professor Gregory, which bears on the most modern aspect of mining in this country: "Years ago Bendigo was described as exhausted, but the mining industry is still flourishing there. It shows the deepest gold mining in the world. . . . . It was at first famous for its alluvial gravels, and then for the exceptional richness of its 'blows' of quartz, which stood up in crags, owing to the wearing away of the softer slates. The quartz 'blows' seen on the surface were soon crushed, and the miners followed them underground. This work led to the disappointing discovery that the quartz-veins, instead of continuing to unknown depths, became thinner, and soon pinched out." Ultimately it was discovered that these wedge-like reefs were found to be the lower sides of arches of vein-quartz, which were connected with arch-like foldings in the country rocks; hence the lodes were called 'saddle reefs.' It is to the systematic exploitation of these 'saddle reefs,' so well described by Professor Gregory, that the continued success of gold-mining at Bendigo is due. He then proceeds to speak of Castlemaine, where the surface-gravels were phenomenally rich, whereas the quartz-lodes have been poor. He suggests that here the gold-mines are close to intrusive granitic rocks, causing much secondary concentration. This material has been removed by denudation, forming the rich alluvial deposits, and only the roots of the gold shoots remain.

Victorian geology presents many other points of interest; and the Carboniferous system, though not rich in workable coal, possesses its

own special features. Thus, he says, that the Upper Carboniferous is represented by the "famous glacial deposits and boulder-clays of Bacchus Marsh, Heathcote, Bendigo, the Lodden Valley, and Southern Gippsland. These beds are unquestionably of glacial origin, as they contain polished and ice-scratched boulders, and rest upon rock surfaces which have been ground and worn by ice-action. The boulder beds are associated in places with lake deposits, but as a whole they are stratified tills." It is unfortunate that these beds have not yielded any contemporary fossils, as it would be instructive to ascertain what the fauna and flora of this early glacial period was like. The glacial beds of Bacchus Marsh are overlaid by a series of sandstones which contain the leaves of *Gangamopteris*, and would seem to be on the horizon of the Greta or Lower Coal-measures of New South Wales. The Permo-Carboniferous deposits of New South Wales, with their rich coal-seams, have not been discovered in Victoria.

Another interesting feature of this colony or state is the enormous development of Tertiary volcanics, especially in the south-west corner. The older Victorian basalts, or lavas, are associated with Middle Cainozoic beds, and were succeeded by basalts of a later period, which have been less denuded and decomposed. Still later occurred another series of volcanic eruptions, which piled up a number of craters, even now in a fairly good state of preservation. The best exposed vent of the older basaltic eruptions is the deeply dissected stump of a volcano two miles north-west of Bacchus Marsh. Here, then, the geologist may study side by side the phenomena of Frost and Fire.

South Australia.—This is somewhat of a misnomer, seeing that the colony extends right across the continent from south to north as far as the Gulf of Carpentaria. The highlands of South Australia, clinging to the south coast, serve to connect the old Archæan plateau of Westralia with the Palæozoic highlands of eastern Australia, and in this region there is great variety of rock-formation, although the Cambrian is best represented. The great physical feature of South Australia is the Lake Eyre basin. This is now usually a plain of salt lakes and salt swamps; vast floods from the Queensland hills are poured into it, and the lake for a time contains salt water, but this soon evaporates, leaving only a chain of briny water-holes. This great basin is bounded on the south by the previously mentioned South Australian highlands, and on the west by the Peak and Denison ranges, whilst the slopes towards Queensland and New South Wales on the north and east are very gradual. The clays of Cretaceous age in the Lake Eyre basin imprison vast stores of water; the fossils obtained in fragments from the numerous boreholes include Cretaceous mollusca, e.g., two species of Belemnite, *Cyloceras australe*, Moore, *Pinna australis*, Hudl., etc., etc. There are also much later deposits, which may be Upper Pliocene or Pleistocene, of a detrital character, rich in *Diprotodon*, the bones of crocodiles, giant lizards, and water-birds; but no signs of contemporary man have been found.

This seems the proper place to consider the very interesting subject of the Flowing Wells of East Central Australia, noted by Dr. Gregory in the present volume (p. 161) and also in the "Dead Heart of

Australia." Between the Western Plateau of Australia and the East Australian highlands lie the great plains of East Central Australia, which are for the most part arid, and contain little or no surface-water. But deep below the surface there are sands and shales saturated with water, which is under such high pressure that, when bores are sunk through the clays forming the top of the underground reservoir, the water rushes up the borehole to the surface and discharges as a flowing well; there are also natural outlets for this pent-up water. In 1882 Dr. R. L. Jack concluded from the geological structure of Queensland that a supply of artesian water might occur in the west of that state. A borehole was completed in 1888, a water-bearing layer being reached at a depth of 1,645 feet, when the water rose to the surface and discharged nearly 300,000 gallons a day. Since then, alike in New South Wales, in Queensland, and in South Australia, numerous 'artesian' wells have been sunk, the deepest being 5,046 feet; some of this water is warm and much of it highly saline.

The author accepts the term 'artesian' in a general sense, and observes that the rise of water in these wells has been attributed to the hydrostatic pressure of the water occurring in the same layer of rock at a higher level in the Queensland hills. It was thought, for instance, that the wells were supplied by the percolation of rain- and river-water through a porous stratum extending in a continuous layer under the clays of the Rolling Downs formation so characteristic of the central plains.

The well-water was thought to be meteoric water which had fallen on the eastern hills and was thence flowing westwards, as a subterranean river, on its way towards the southern sea. It has been proved, however, that the porous stratum in question is a limited formation quite unable to supply all the wells that have been sunk; many of them derive their water from the shales and mudstones of the Jurassic beds. In the "Dead Heart of Australia" the author has pointed out that the simple artesian theory does not explain the facts. The chemical characters of the well-waters, the thermal phenomena, the irregular distribution of the water pressure, the association of the water with various gases, and the tidal rise-and-fall of the water in some of the wells present a series of phenomena none of which agree with the hydrostatic theory. He expresses a belief that the ascent of water in these boreholes is mainly due to the tension of the included gases under the pressure of the overlying sheets of rock. Much of the water is an old accumulation, some of which may have been derived by percolation from meteoric sources; much of it is probably of plutonic origin, having risen through deep springs from the underlying rocks, and some of it may be old sea-water in the Cretaceous beds. Opinion inclines to the view that there is no fear of exhausting the artesian water, but the author believes that the existing waste is unfortunate, since the supply may not prove inexhaustible.

Professor Gregory seems to have arrived at this modified 'artesian' theory slowly and by degrees. Those who have read his interesting explanation of the hydrostatic conditions as applied to the hill-country

of Queensland, in connection with the underground waters of the plains, must needs confess to a certain amount of disappointment that such elaborate calculations have only a partial and limited relation to the phenomena of the Flowing Wells as a whole. The difficulty of uniform explanation increases in proportion to the extent of country exploited, and this extent, in the case of East Central Australia, is so immense that many causes may conduce to the uprise of water in the innumerable borcholes sunk throughout this vast region. Still, the hydrostatic or ordinary artesian theory may be applicable in the majority of those cases where the well-water is fresh and of normal temperature. There seems a reasonable degree of probability that much of this water is really meteoric, and therefore perennial so long as present climatic conditions prevail. The stale waters of old seas such as the Cretaceous, or waters of "plutonic origin,' can be of little service from an economic point of view, and therefore the waste of these is not of much consequence, though their discharge in the form of flowing wells may tend to increase the already too great salinity of the surface. No doubt it must be a sad disappointment for the Australian prospector, after spending thousands of pounds in boring thousands of feet, to obtain a mixture of salt and water for his pains. Nevertheless, such mishaps sometimes occur in the old country, as was the case recently at Lincoln, where a costly borehole sunk to a depth of slightly over 2,000 feet brought up a copious supply from the Trias, which, it was hoped, would purify itself by degrees; but at present the only use for such a genuine artesian overflow would be the establishment of warm salt-water baths in an inland city.

Westralia.—We have already seen that the immense territory included under this name consists mainly of Archæan and Old Palæozoic rocks, with a coastal fringe of newer rocks which runs from 20 to 30 miles in width ere the face of the plateau is reached. From its western edge this plateau is a broad undulating tract, mostly between 1,000 and 2,000 feet in elevation up to the confines of South Australia on the east. Except in the extreme south where the Stirling Range attains 3,640 feet, and in the far north where Mount Bruce rises to 3,800 feet, the features of the country are extremely monotonous. The main interest in the Archæan plateau centres in its mineral wealth, since all the goldfields of Westralia occur in it. Harry Page Woodward divided the Archæan rocks into six parallel belts. No. 1 forms the base of the coastal district on the west, and the greater part of this belt is covered by later deposits. No. 2 is exposed in the scarp that forms the west face of the plateau. No. 3 is the first granite belt, and is devoid of minerals. No. 4 is the first auriferous belt. No. 5 is the second granite belt. No. 6, or the second auriferous belt, is the easternmost of the series, and it is in this that the famous goldfields of Coolgardie and Kalgoorlie occur. The rocks of both auriferous belts consist mainly of schists, of which the most important is a series of amphibolites, and there are also numerous dykes of granite, diorite, and porphyrite. "Bands of the amphibolites have been so crushed that they often resemble altered slates, and others have been silicified into jasperoid, and mineralized into the rich lodes of the Kalgoorlie goldfield."

The most varied district in Westralia from a geological point of view is that of Kimberley in the extreme north-west of the state. The foundation of the Palæozoic plateau here consists of Cambrian rocks. The age of these rocks is proved by the fact that they contain worms of the genus *Salterella*, and a trilobite which is referred to *Olenellus*; the first payable goldfield discovered in Westralia is situated in these rocks. There are also indications of Silurian beds, and the Devonian system is said to be well developed in the Kimberley district, though not indicated in the geological map (p. 104). In this region also the map shows Carboniferous rocks and large patches of Tertiary volcanics.

It is, however, in the basin of the Gascoyne River, an expansion of the western coastal strip, that the most interesting development of beds of Carboniferous age occur. In all this region they belong, in the main, to the marine limestone type of the Lower Carboniferous. These beds are rich in fossil corals and in Polyzoa of a peculiar character, such as the genus *Exactinopora*, originally described from the Lower Carboniferous of Illinois and Iowa in the United States of America. There is also an abundance of characteristic Brachiopoda, etc. Beneath the Carboniferous limestones are shales and conglomerates along with beds containing coarse boulders, some of which are considered to be of glacial origin. On the south the Irwin River Coalfield constitutes the third chief outcrop of the Carboniferous beds, and this is considered to be of Permo-Carboniferous age from the fossils associated with the coal deposits. The development is considered to be a poor one, and, so far as is known, Westralia is not likely to be a coal-producing district to any extent.

The Mesozoic and Cainozoic rocks in the coastal strip are not of particular importance, except that in some cases, when reached by bores, certain Mesozoic rocks yield abundant water through artesian wells; most of the fossils indicate a Lower Jurassic age, though there is some evidence of Lower Cretaceous. A series of Cainozoic deposits rests on the Archæan plateau of the interior; it includes vast sheets of mottled clays, ironstones, and conglomerates. These clays have yielded the bones of *Diprotodon*, and they also contain patches of lime, coal, and cement, which is sometimes rich in gold. Race and laterite are abundantly deposited on the surface.

Westralia has of late been the chief gold-producing state of Australia, as the following figures for the year 1903 will show:—

	£
Western Australia	8,777,719
Victoria	3,259,485
Queensland	2,889,813
New South Wales	1,080,029
South Australia	90,031
Total	£16,047,075

W. H. H.